DATA HARVEST

EASYSENSE

Qt Digital Timer

user manual

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What's in the storage case

The Qt Digital Timer

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EasySense Software
and Documentation
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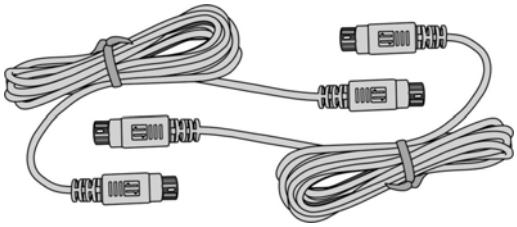
Tel. +44 (0) 1525 373666
Fax. +44 (0)1525 851638
If this CD does not run automatically, click on
Setup.exe and follow the instructions on screen.
The EasySense software requires a Windows PC
(XP or Later) and a free USB port.
Multi-user licence.
© Data Harvest Group Ltd. 2012
Product no. 4500

The **EASY**SENSE software

A power supply unit (UK version shown)



Two long *Smart Q* sensor leads

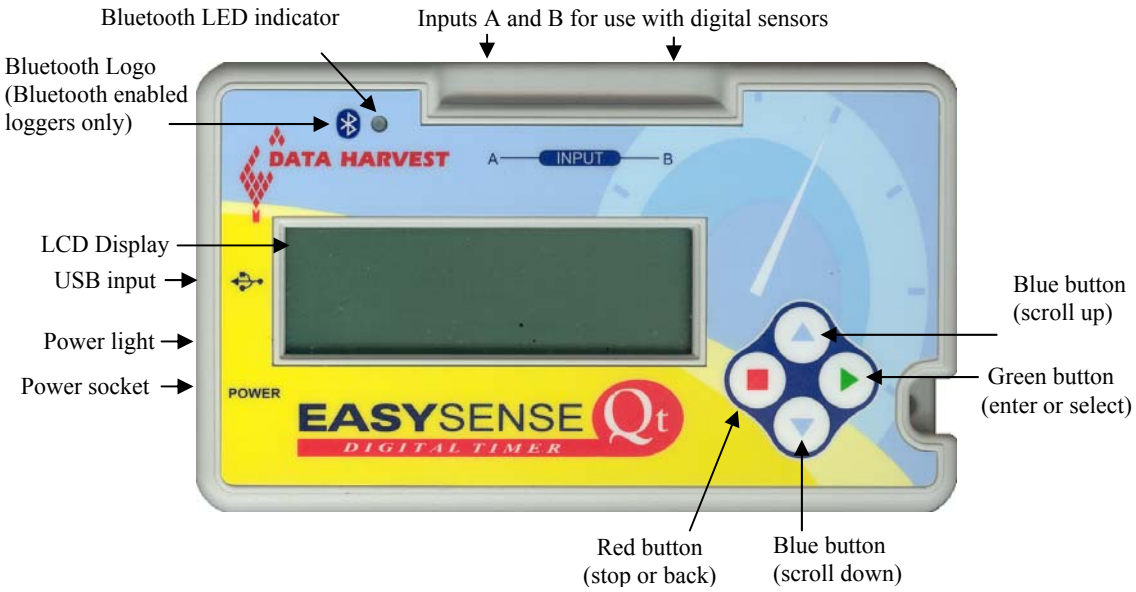
A USB communication cable

Charge Qt Timer for 12 hours before first use

The Qt Digital Timer

Qt Timer is a fully self-contained portable data logger, which can be used:

1. As an interface connected to a computer to record timing data from digital switch-type sensors
2. As a stand alone instrument. In stand alone mode Qt Timer will record time, speed and acceleration data from digital switch-type sensors to its memory. The measurements can be reviewed on the unit or transferred to a computer.



Qt Timer buttons

The green button (ENTER) is used to start data collection or to confirm a choice.

The red button (STOP) is used to stop data being recorded or return to the previous screen.

The blue buttons (SCROLL) are used to scroll through menus on the LCD screen or to browse measurements.

To wake up the logger press any of the buttons on the top panel.

Smart Q Sensors

The two inputs on Qt Timer are for use with switch-type (digital) sensors such as Light gates, Timing mats, Crocodile clip leads, and Push-button reaction switches. To maintain consistency with existing software, the inputs are labelled as A and B.

Digital sensors measure ON/OFF conditions and are used to study Time, Speed, Velocity, Acceleration, Momentum and Kinetic Energy relationships. They are available to purchase separately, please contact your supplier for an up-to-date list.

Two long sensor leads have been provided to connect digital sensors. Connect one end of the sensor cable to the shaped input socket on the logger and the other end to the sensor.

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Ways to capture data with Qt Timer

1. **PC connected**. In this mode Qt Timer is entirely driven by the software on the host computer. The data from the digital sensors is transmitted immediately to the computer and displayed on the computers screen using the Timing application in the EasySense software.

2. **Stand alone**. In this mode Qt Timer is used to collect and store data while disconnected from the computer. Data collection can be set up using the logger's menu options (e.g. Time, Speed, and Acceleration – see page 9). The measurements are stored in the memory of the logger as a set of data. Measurements can be reviewed on the unit or transferred to a computer for further analysis (see page 20).

Using Qt Timer connected to a computer for the first time

Step 1:

Do **NOT** connect Qt Timer to the USB port before the EasySense software is installed.

Install the EasySense software, if it is not already on your computer. For details of how to install and operate this program, please refer to the instructions provided with the software.

Qt Timer requires **version 2.5** or above of the EasySense software (the version number can be verified in About from the Help menu).

Step 2:

a) If Qt Timer is to be connected via the **USB port**, the USB drivers will need to be installed.

- Connect the 'square' USB plug of the USB cable to the USB input on the side of the logger.
- Connect the 'flat' USB plug to a USB port on your computer.
- Windows will automatically detect a new device and install the drivers.

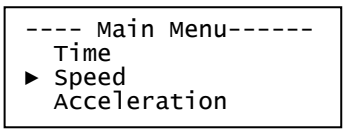
b) If Qt Timer is to be 'connected' via **Bluetooth™** use the instructions provided on page 27.

Notes:

- To 'connect' via Bluetooth Qt Timer must have Bluetooth built-in. This will be indicated by a Bluetooth symbol above the Data Harvest logo.
- If you wish to add Bluetooth functionality to your logger, please contact Data Harvest for information about a Bluetooth upgrade.

Step 3:

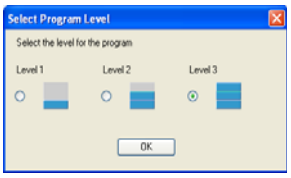
- Check that the LCD screen on Qt Timer is displaying the 'Main Menu'.



- Open the EasySense software program.

Step 4:

The first time the EasySense program is opened a 'Select Program Level' window will automatically open. Select a suitable user's level.

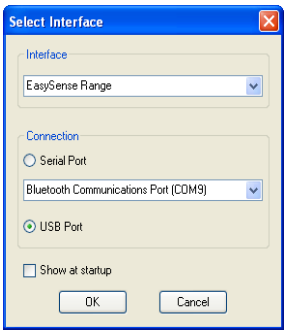


- Level 1 is aimed at 'start' level (e.g. up to 9 years old).
- Level 2 is aimed at 'mid' level (e.g. 9 – 15 years old)
- Level 3 is aimed at 'exam' level (e.g.15 years plus).

Note: The program level can be altered at anytime using the Level icon once a logging option has been opened.

Step 5:

An Interface option window will open.



- Select the Interface as **EASY**SENSE Range.
- Select the method of connection
  - If connecting via the **USB port** select 'USB port'.
  - If connecting via **Bluetooth**, select Serial port and then the serial (COM) port configured for Bluetooth from the drop down menu.

  Note: If you use different interfaces or methods of connection, tick the 'Show at startup' option so you can check your current selection and make any adjustments each time EasySense opens. If you change connection from Bluetooth to USB, check that Bluetooth on Qt Timer is switched OFF.

- Click on OK. The program will save your selection so it will be automatically configured when next used.
- When a connection is established the Home screen will open. Select the appropriate option e.g. Timing.

Using Qt Timer with the computer after initial setup

- **USB users:** Connect Qt Timer to the computer.

  Bluetooth users: If the display is turned off, press any button to wake up the logger. If the blue LED doesn't light check that Bluetooth is On (System menu ► Bluetooth menu ► Bluetooth On/Off).

- Open the EasySense software and select the appropriate option e.g. Timing from the Home screen.

Note for Bluetooth users: If Qt Timer is operating on battery power it will automatically switch itself off if not used for five minutes. When Qt is off (LCD display is blank) it will not be able to communicate with the EasySense software. To prevent auto switch off connect Qt to its main power supply.

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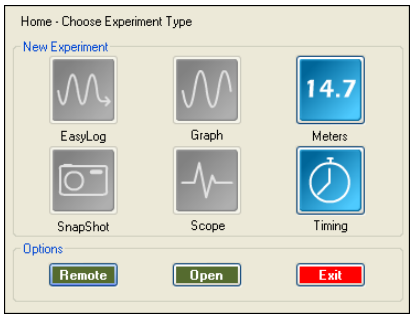
The EASYSENSE software overview



Home is the main navigation window with the icons for Qt Timer's logging options.

Note: EasyLog, Snapshot, Graph, Scope and Setup Remote cannot be used with the Qt and so will not be available.

Meters
The Meters window gives an introduction to sensors and how they respond to change. Up to four section displays can be open at any one time and they can be any combination of sensors and displays.

The program will open with live data from one sensor in a Numeric window. Click on the appropriate picture icon on the tool bar to open other section displays i.e. Numeric, Gauge, Colour Change or Bar. To alter the sensor displayed in a section, **right** click in the individual section window and select the sensor from the list.

Click on the Start/**Stop** icon to stop recording.

Timing
Timing is used to allow students to study Time, Velocity, Acceleration, Momentum and Kinetic Energy relationships using switch-type (digital) sensors such as Light gates connected to input 5:A or 5:A and 6:B.

A wizard will open with the recording options available (these will depend on the user level selected). When the selection has been made, click on Finish.

Click on the **Start**/Stop icon and a reading will be displayed when a change is detected in signal from the digital sensors.

Click on the Start/**Stop** icon to stop data being recorded.

Counting **(Level 1 and 2 only)**
Use to count events by using switch-type (digital) sensors connected to input A or A and B. The program will open pre-set to display a count as a number and horizontal bar graph.

Click on the **Start**/Stop icon , each time the state of a sensor is changed to On e.g. by pressing a push switch, the number of counts will advanced by one.

Click on the Start/**Stop** icon to stop data being recorded.

Retrieve Remote
Use this option to retrieve a data set stored in Qt Timer's memory. A dialogue box will open showing the list of data sets currently stored. The most recent data set is first in the list. Select the required set of data and click on **Retrieve**.

Notes: If the Erase data box is ticked, the set of data selected will be erased from the logger after retrieval.

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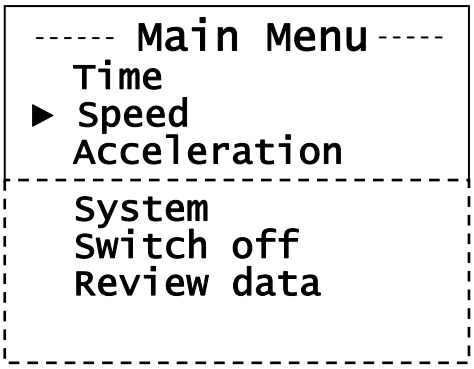
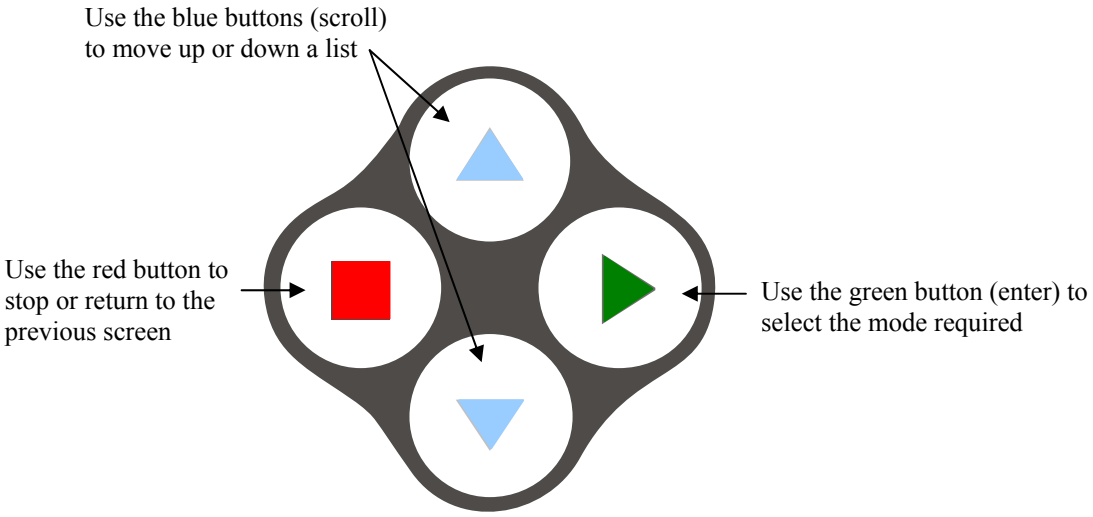
Using Qt Timer without a computer

Qt Timer has a menu of different options available, which are displayed on the built-in LCD screen.



A menu option is selected by using the blue buttons to move the list up △ or down ▽ until the pointer is pointing at the required option (the pointer stays in the same position). Press the green ▶ button to select.


Use the blue buttons (scroll) to move up or down a list
Use the red button to stop or return to the previous screen
Use the green button (enter) to select the mode required

Qt Timer has no ON switch. To 'switch' **on** press any button on the top panel.

If Qt Timer is operating on battery power and is not being used, it will automatically switch itself **off** (after five minutes with Bluetooth On, two minutes with No Bluetooth or Bluetooth Off). Press any button to resume operation. Qt Timer will not auto switch off when accepting power from either the USB port or a mains power supply.

Timing

There are three main Timing options, Time, Speed and Acceleration which set up for collecting measurements from either one digital sensor connected to Input A, or two connected to Input A and Input B.

Speed, Velocity and **Acceleration** are calculated by Qt using time data and the dimensions of the interrupter used in an investigation.

$$\text{E.g. Speed at A} = \frac{\text{Length of single interrupt card}}{\text{Time}}$$

The choice of interrupter and its dimensions are preset in Qt's memory. See page 12 for the list of interrupts and the choice of preset dimensions e.g. a single interrupt card can be 30, 40, 50, 95, 100 or 120 mm in length.

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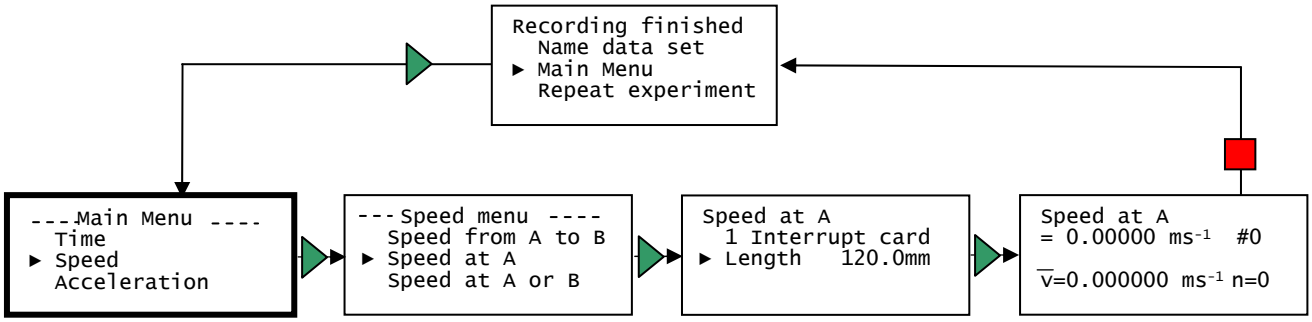
Example: Speed at A.



- Either connect a digital sensor to Input **A** or a pair of digital sensors to Input **A** and **B.** If the display is turned off, press any button to wake up Qt Timer.

- Use the blue up/down buttons to scroll the menu until the pointer is pointing at the required option i.e. Time, Speed or Acceleration. Press the green button to select.

```
---- Main Menu----
  Review data
▶ Time
  Speed
```

- Use the blue up/down buttons to scroll the menu until the pointer is pointing at the required option. Press the green button to select.

```
--- Time menu -----
  Stopwatch A to A
▶ Time at A
  Time at A or B
  Time from A to B
  Period at A
```

```
--- Speed menu ----
  Speed from A to B
▶ Speed at A
  Speed at A or B
  3 Speeds at A or B
```

```
- Acceleration menu -

▶ Accel. at A
  Accel. A to B
```

- If **Speed** or **Acceleration** is selected enter the choice of interrupt and its measurement:

  Line 2 - scroll through the list of interrupters to find the type you are going to use. Press the green button to select.

```
Speed at A
▶ 1 Interrupt card
  Length  30.0mm
```

  Line 3 – scroll through the list of dimensions and select to be size used. Press the green button to select.

```
Speed at A
  1 Interrupt card
▶ Length  30.0mm
```

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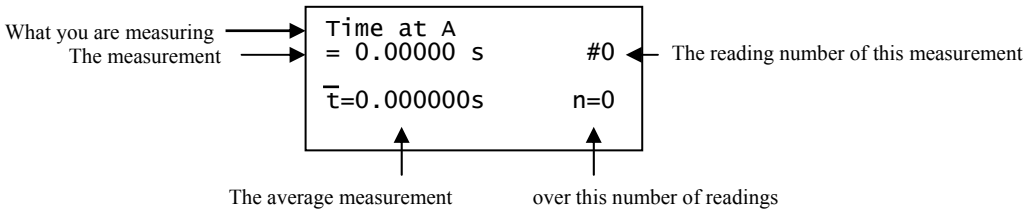
Line 1 – What is being measured	Line 2 – Interrupter	Line 3 – Measurements available to select
Speed at A	1 Interrupt card ■	Length of card = 30, 40, 50, 95, 100 or 120 mm
	2 Interrupt card ■ ■	Length of segment = 30, 40, 50, 95, 100 or 120 mm
	Picket fence ■ ■ ■ ■	Pitch (width of black + clear stripe) = 10, 20, 40, 60 or 80 mm
	10 Spoked pulley ☼	For use with the Data Harvest Spoked Pulley (Product No. 3177), 47 mm in diameter
Speed at A or B	1 Interrupt card ■	Length of card = 30, 40, 50, 95, 100 or 120 mm
3 Speeds at A or B	1 Interrupt card ■	Length of card = 30, 40, 50, 95, 100 or 120 mm
Speed from A to B	Distance A to B	Distance between A and B = 100, 200, 300, 400, 500, 600, 700, 800, 900 mm, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 m
Accel. at A	2 Interrupt card ■ ■	Length of segment = 30, 40, 50, 95, 100 or 120 mm
	Picket fence ■ ■ ■ ■	Pitch (width of black + clear stripe) = 10, 20, 40, 60 or 80 mm
	10 Spoked pulley ☼	For use with the Data Harvest Spoked Pulley (Product No. 3177) - 47 mm in diameter
Accel. A or B	1 Interrupt card ■	Length of card = 30, 40, 50, 95, 100 or 120 mm

- Qt Timer will be ready to start taking measurements. When a signal change from the digital sensor/sensors is received, the timing measurement will be displayed in seconds (s) on the LCD screen.

  Example:



  The second line shows the current reading, the # number indicates the number of the reading. The blue up/down buttons ⇕ can be used to scroll back and forward through the readings already taken, the # number will indicate the reading number of the measurement shown.

  The bottom line shows the average measurement and number of readings used to calculate this average.

- Press the red button to finish or cancel. The LCD will show the 'recording finished' menu and the data set will be stored.

- Either press the green button to return to the **Main Menu**, or scroll to Repeat experiment, Delete data set? or Name data set.

```
Recording finished
  Name data set
▶ Main Menu
  Repeat experiment
  Delete data set?
```

Repeat experiment will take you direct back to the recording window.

Name data set will open a window in which text or numbers can be selected for the name of the data set. Use the blue up/down buttons to scroll through the letters and numbers. Press the green button to select as appropriate. The list starts each time at the same point**;** use the up button to go through the numbers, and the down button to go through the alphabet. Press the red button to finish and go back to the recording finished menu.

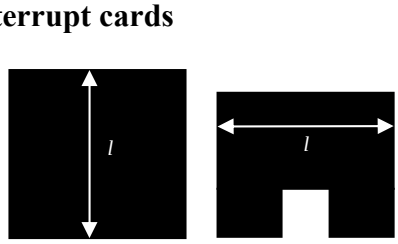
```
Name data set:

a
```

Delete data set? Use to delete the set of data just created. Press the green button to confirm your choice and then the red button to return to the main menu.

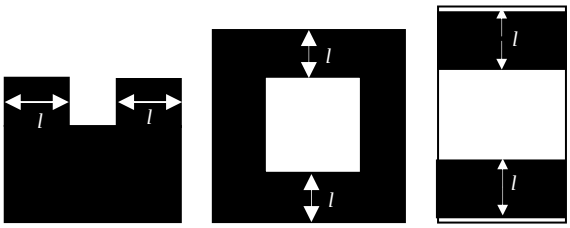
- The measurements can be reviewed on the unit or the data set can be downloaded to the computer using Remote, **Retrieve Remote** from the Home screen in the EasySense software.

Interrupters and parameters

Interrupt cards

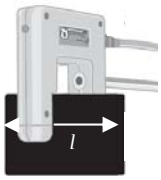


Single Interrupt card



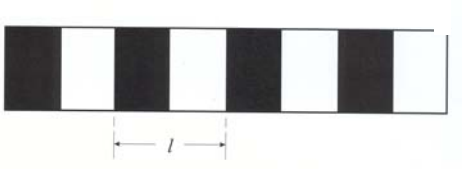
Double Interrupt cards

Preset values are **30.0, 40.0, 50.0, 95.0, 100.0 and 120.0 mm**.



Measure the solid part of the card that will pass through the Light Gate. The two segments of a double interrupt card must be equal in width.

Multi-segmented card (Picket fence)
Preset values of pitch are = **10.0, 20.0, 40.0, 60.0, 80.0 mm**.



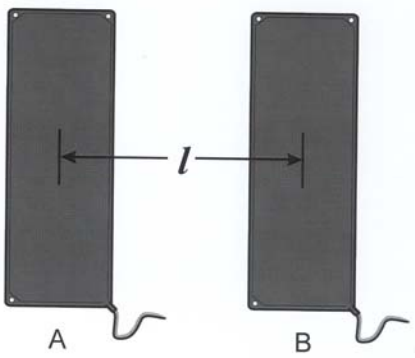
Picket fence

Measure from the start of one black edge to the start of the next black edge.

10 Spoked Pulley
The measurements for the Data Harvest Spoked Pulley are pre-defined.

Distance
Preset values are **100, 200, 300, 400, 500, 600, 700, 800, 900 mm, 1.0, 2.0, 3.0, 4.0, 5.0** or **6.0 m**

Measure from the sensor connected to Input A to the sensor at Input B. E.g. with Timing mats measure from the centre of one mat to the centre of the other mat.



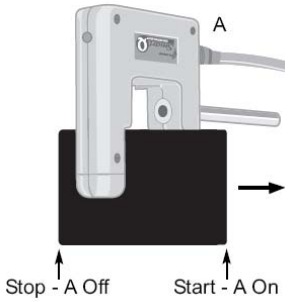
Timing mats

Timing options

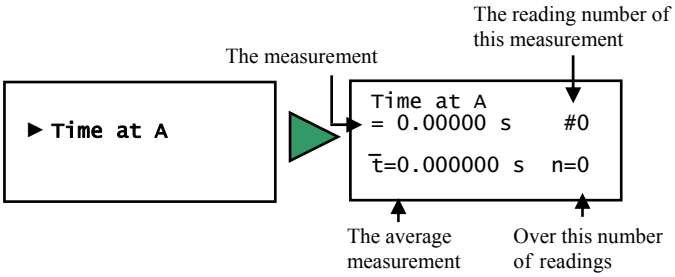
Time at A

Timing starts when the signal at input A changes and stops when the signal reverts back.

- With Light Gates it will be the time it takes for an object to pass through the light beam.
- For a Push Switch it will be the length of time that the switch is kept depressed.
- For Timing mats it will be the length of time someone stands on the mat.

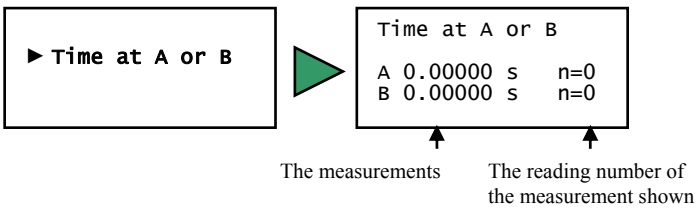


Use the blue buttons ⯁ to scroll through and examine the readings already taken.



Time at A or B

A measurement will be taken each time a signal change is detected at **either** sensor A or sensor B. The current measurement from A or B will be displayed on the LCD screen.



Note: This type of data cannot be displayed using the review data option on Q. To review the data download the data set via Remote, **Retrieve Remote** in the EasySense software.

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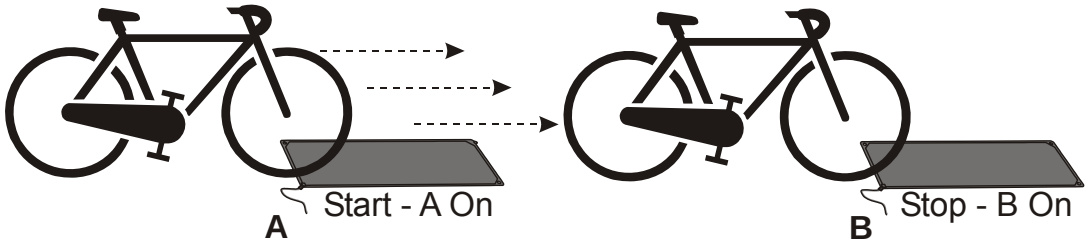
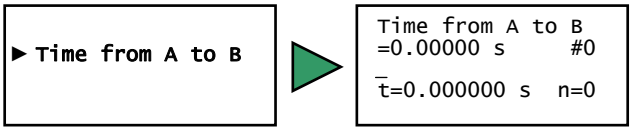
Time from A to B

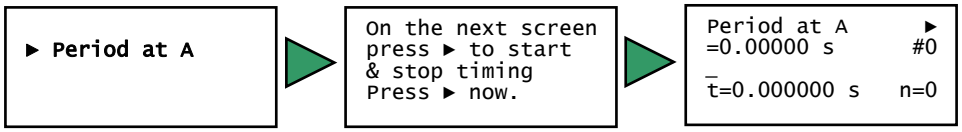


Timing will start when a signal change is detected at sensor A and stops when the signal at B changes (so it measures the time taken by an object to travel from sensor A to sensor B).



Use the blue buttons to scroll through and examine the readings already taken.

Period at A

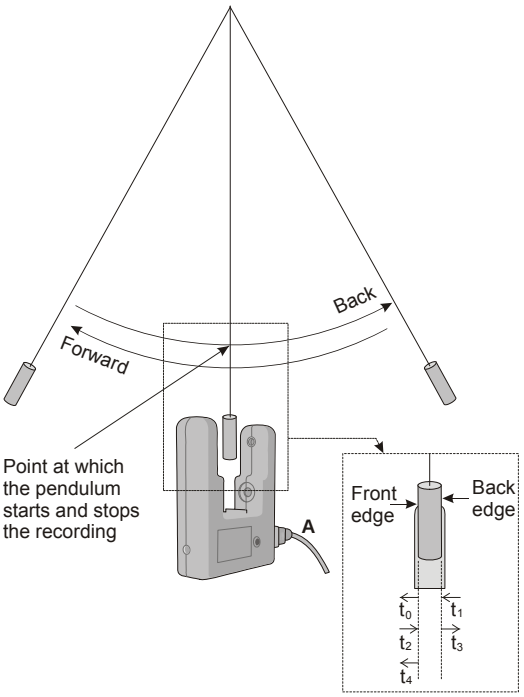


Start the pendulum swinging, and when it is moving freely press the green ▶ button on Qt to start timing (the ▶ symbol will disappear from the first line).

The time will start to be measured when the pendulum first passes through the Light gate, it will ignore the second signal change (when the pendulum passes back through) and will stop at the third change (when the pendulum arrives back at the Light gate). The display will show the time for a complete period.

Press the green ▶ button on Qt to pause timing (the ▶ symbol will reappear in the first line). Use the blue buttons to scroll through and examine the data.

Press the green ▶ button on Qt to continue timing or the red ■ button to finish.



Period at A measures $t_0 \rightarrow t_4$
t_0 = Start (front edge of pendulum passes light gate – going forward)
t_1 = ignored (back edge of pendulum passes light gate – going forward)
t_2 = ignored (back edge of pendulum passes light gate – going back)
t_3 = ignored (front edge of pendulum passes light gate – going back)
t_4 = Stop (front edge of pendulum passes light gate – going forward)

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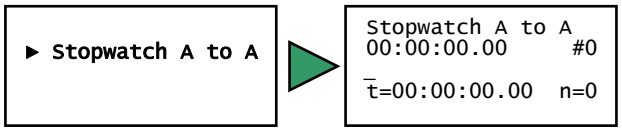
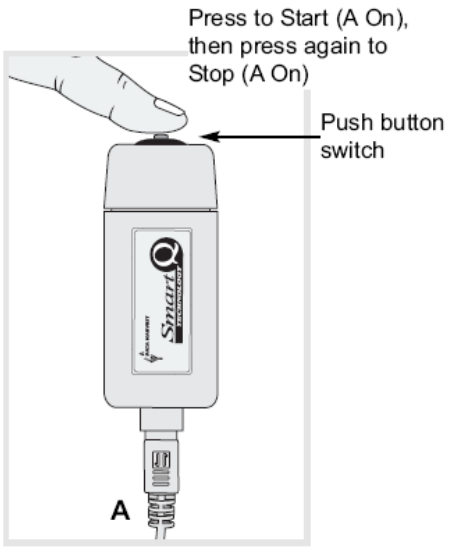
Stopwatch A to A





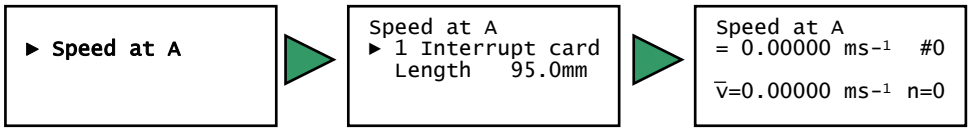
The time will start to be measured when the signal at input A changes (ON) and will continue until the signal at A changes again (ON) i.e. like a stopwatch.

Use the blue buttons ⇕ to scroll through and examine the readings already taken.

Speed at A

Timing will start when the signal at input A changes and stops when the signal changes back.

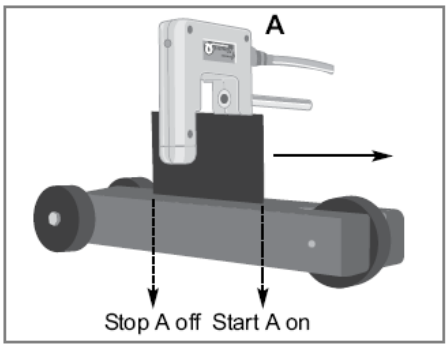
Single interrupt card



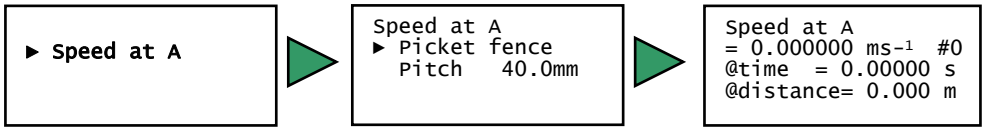
When a single interrupt card passes through a Light gate, the time measured is for how long the card took to pass through the Sensor.

Speed is calculated using the length of the interrupt card divided by the time taken for the card to pass.

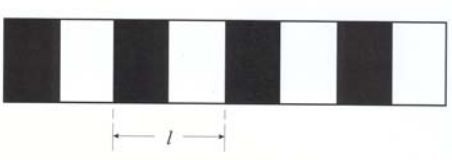
Use the blue buttons ⇕ to scroll through and examine the readings already taken.



Multi-segmented card (Picket fence)



When a picket fence is used to measure Speed at A, the measurements shown are for instantaneous speed i.e. at this distance, the speed was. This data can be used to plot a distance vs. time or instantaneous speed vs. time graph



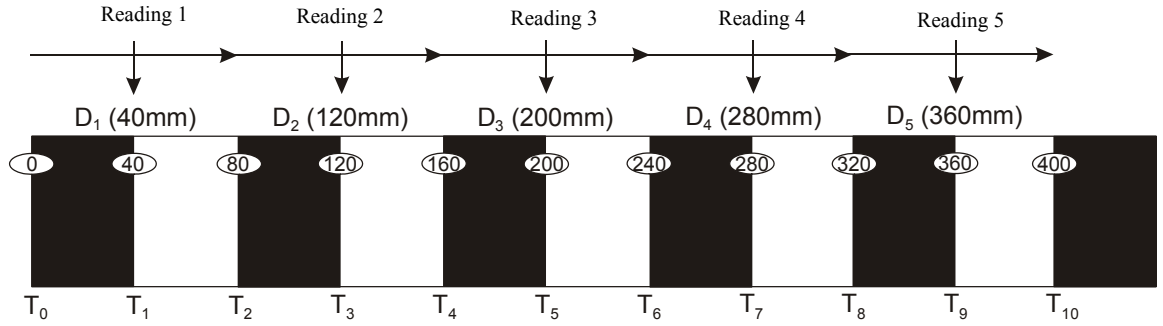
Picket fence

To improve the accuracy of readings, an increment is automatically applied to a picket fence with a pitch length of less than 60 mm. This will mean that there are fewer readings than number of pitches on a fence.

Note: It is envisaged that when a picket fence with a pitch length of 10 mm is used that it will be used on a buggy type investigations (which produce slower times than dropping thorough Light gates) the times are therefore averaged over less pitches

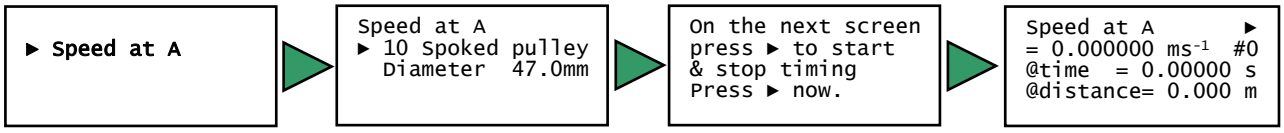
Pitch length (*l*)	Readings taken with a pitch increment of:
80 mm	1 (80 x 1 = 80 mm)
60mm	1 (60 x 1 = 60 mm)
40 mm	2 (40 x 2 = 80 mm)
20 mm	4 (20 x 4 = 80 mm)
10 mm	5 (10 x 5 = 50 mm)

For example: (*l)* = **80 mm** - readings taken with a pitch increment of 1 (80 mm).

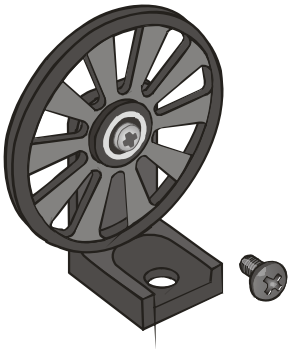


Reading 1 = $\frac{l}{T_2 - T_0}$	Reading 2 = $\frac{l}{T_4 - T_2}$	Reading 3 = $\frac{l}{T_6 - T_4}$	Reading 4 = $\frac{l}{T_8 - T_6}$	Reading 5 = $\frac{l}{T_{10} - T_8}$

Spoked Pulley



When a Spoked Pulley is used to measure Speed at A, the measurements shown are for instantaneous speed i.e. it took this amount of time to travel this distance and the speed was. The measurement of the Data Harvest Spoked Pulley is pre-defined.



Set up the investigation but do not press enter on Qt until you are ready to take readings (the spokes on the pulley can easily interrupt the Light gate beam and create false results). When all is ready press the green button on Qt for the ▶ recording to start (the ▶ symbol will disappear from the first line).

Press the green ▶ button on Qt to pause timing (the ▶ symbol will reappear in the first line). Use the blue buttons to scroll through and examine the data.

Press the green ▶ button on Qt to continue timing or the red ■ button to finish.

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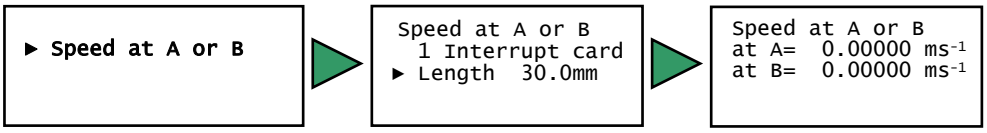
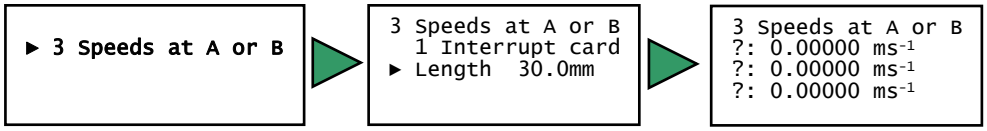
Speed at A or B



A measurement is taken each time a signal change is detected (when an object passes through) **either** sensor A **or** sensor B. The current measurement from A or B will be displayed on the LCD screen.

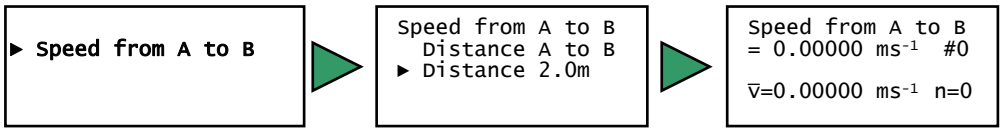
Note: This type of data cannot be displayed using the review data option on Q. To review the data download the data set via Retrieve Remote to the **EASY**SENSE software.

3 Speeds at A or B



Three measurements are taken for a signal change at either sensor A and/or sensor B e.g. for elastic or inelastic collision investigations. To take another three measurements press the red button and select Repeat experiment.

Speed from A to B

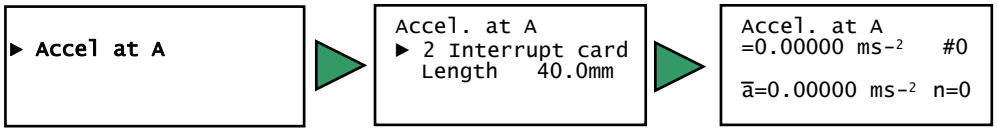


Timing will start when a signal change is detected at sensor A and stop when the signal at B changes (so it measures the speed of at which an object travels from sensor A to sensor B).

Use the blue buttons to scroll through and examine the readings already taken.

Acceleration at A

Double interrupt card



Average acceleration can be measured using a single light gate with a double interrupt card. Acceleration is calculated using the length of the segments on the double interrupt card.

Use the blue buttons to scroll through and examine the readings already taken.

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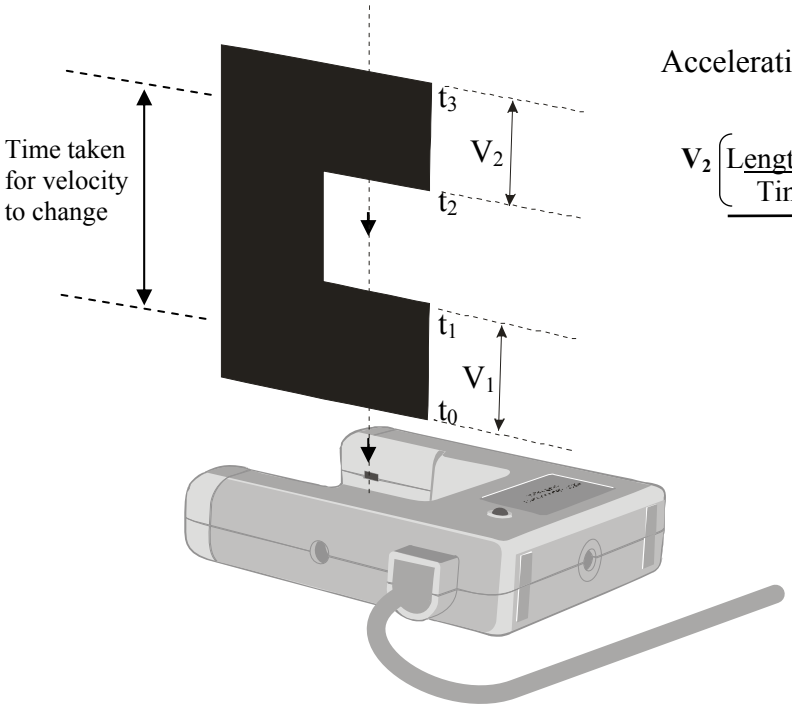
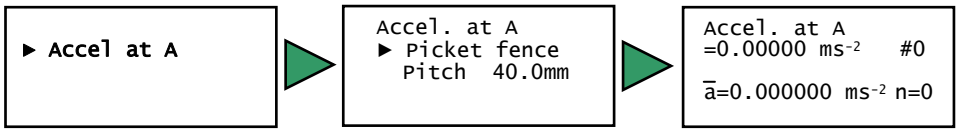


$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Time taken}} = \frac{\mathbf{V_2}\left(\frac{\text{Length of segment}}{\text{Time } (t_3 - t_2)}\right) - \mathbf{V_1}\left(\frac{\text{Length of segment}}{\text{Time } (t_1 - t_0)}\right)}{\text{Time taken}}$$

Picket fence

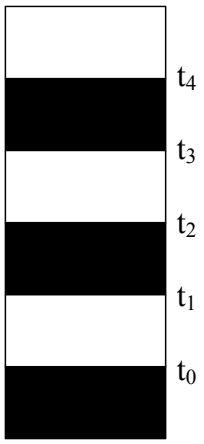


When a picket fence is used to measure Acceleration at A, the measurements shown are for instantaneous acceleration i.e. it took this amount of time to travel this distance and the acceleration was.

Use the blue buttons ⬍ to scroll through and examine the readings already taken.

To improve the accuracy of readings, an increment is automatically applied to a picket fence with a pitch length of less than 60 mm. This will mean that there are fewer readings than number of pitches on a fence.

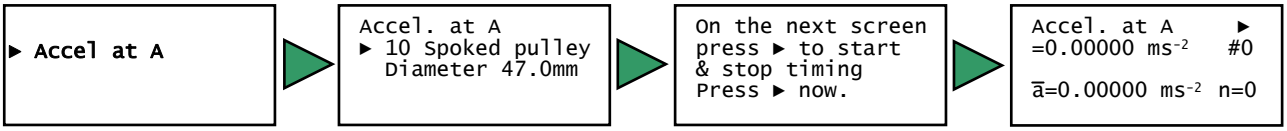
Note: It is envisaged that when a picket fence with a pitch length of 10 mm is used that it will be used on a buggy type investigations (which produce slower times than dropping thorough Light gates), the times are therefore averaged over less pitches.



Instantaneous Acceleration is calculated using the change in Velocity of 2 pitches divided by the time taken for the velocity to change.

$$\frac{\mathbf{V_2 - V_1}}{\frac{t_2 + t_3}{2} - \frac{t_0 + t_1}{2}}$$

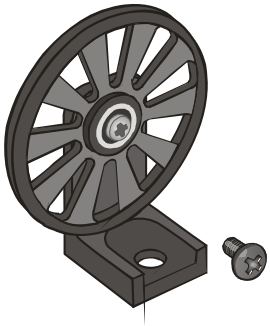
Spoked Pulley



When a Spoked Pulley is used to measure Acceleration at A, the measurements shown are for **instantaneous acceleration** i.e. at this distance, the acceleration was.

The measurement of the Data Harvest Spoked Pulley is pre-defined.

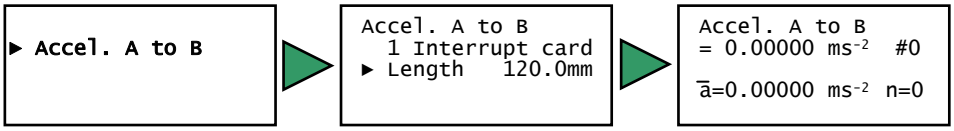
Set up the investigation but do not press enter on Qt until you are ready to take readings (the spokes on the pulley can easily interrupt the light gate beam and create false results). When all is ready press the green ▶ button for the recording to start (the ▶ symbol will disappear from the first line).



Press the green ▶ button on Qt to pause timing (the ▶ symbol will reappear in the first line). Use the blue buttons to scroll through and examine the data.

Press the green ▶ button on Qt to continue timing or the red ■ button to finish.

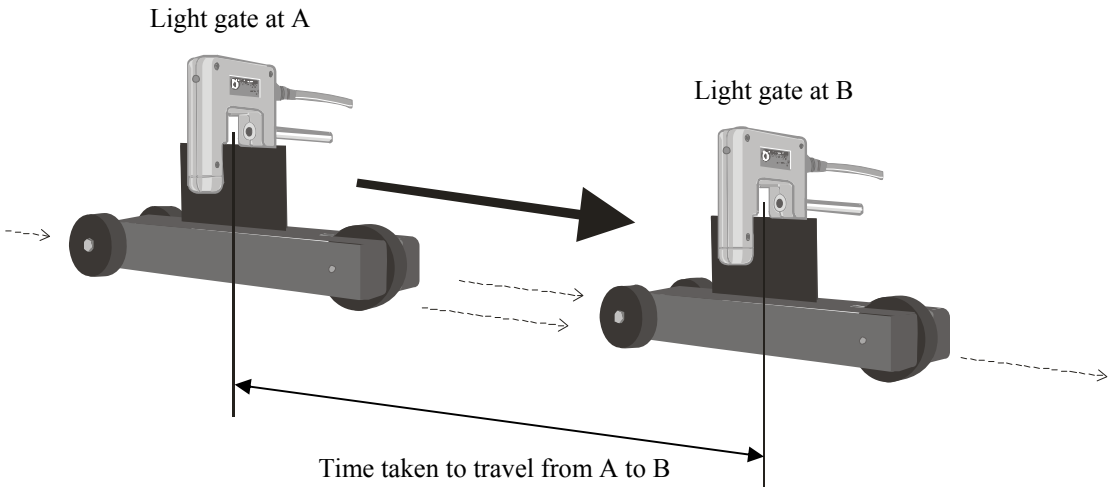
Acceleration A to B



A single interrupt card is used to measure the Velocity at A, the Velocity at B and the time taken to travel from A to B.

$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Time taken}} = \frac{\text{Velocity at B} - \text{Velocity at A}}{\text{Time taken to travel from A to B}}$$

Use the blue buttons ◆ to scroll through and examine the readings already taken.



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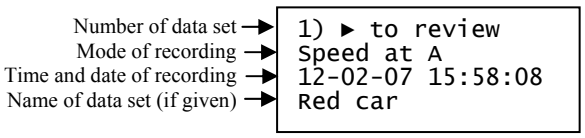
Review data

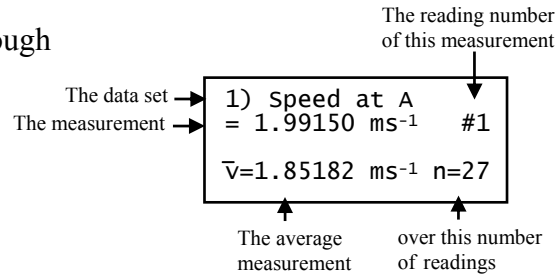
- If the display is turned off, press any button to wake up Qt.
- Use the blue ▲▼ buttons to scroll the Main menu until the pointer is pointing at Review data. Press the green ▶ button to select.

```
---- Main Menu ----
  Switch off
▶ Review data
  Time
```

- Use the blue ▲▼ buttons to scroll through the stored data sets until the required set is selected. Press the green ▶ button to select.



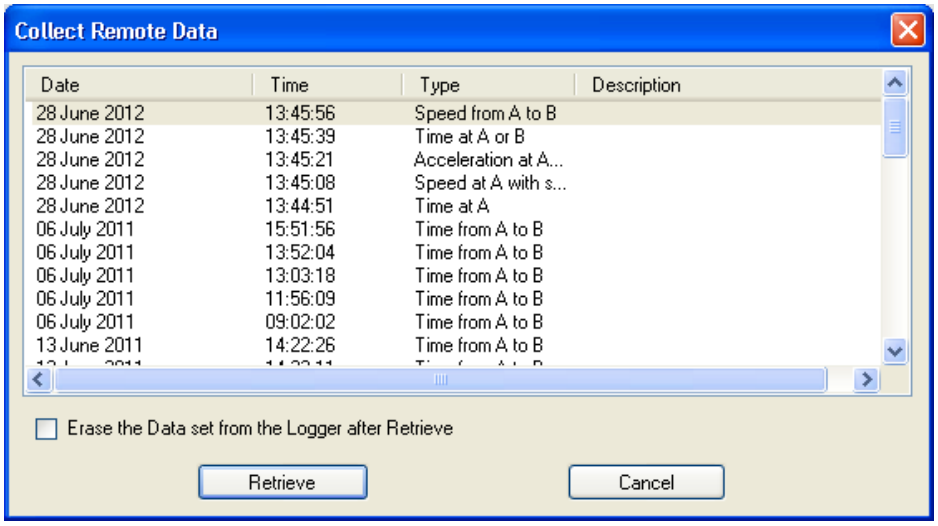
- Use the blue buttons ▲▼ to scroll through and examine the readings.



Downloading stored data sets into the EasySense software

- Connect the Qt Timer to the computer and open the EasySense program.
- Select Remote, **Retrieve Remote** from the Home screen.
- Select the data set from the list and click on Retrieve.

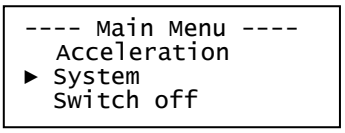
The most recent data set is first in the list.


Collect Remote Data
Date
Time
Type
Description
28 June 2012 13:45:56 Speed from A to B
28 June 2012 13:45:39 Time at A or B
28 June 2012 13:45:21 Acceleration at A...
28 June 2012 13:45:08 Speed at A with s...
28 June 2012 13:44:51 Time at A
06 July 2011 15:51:56 Time from A to B
06 July 2011 13:52:04 Time from A to B
06 July 2011 13:03:18 Time from A to B
06 July 2011 11:56:09 Time from A to B
06 July 2011 09:02:02 Time from A to B
13 June 2011 14:22:26 Time from A to B
Erase the Data set from the Logger after Retrieve
Retrieve
Cancel

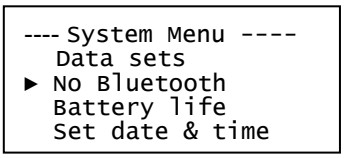
Notes: If the Erase data box is ticked, the set of data selected will be erased from the logger after retrieval.

System menu

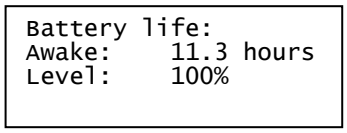
- Use the blue buttons to scroll the menu until the pointer is pointing at System. Press the green button to select.



- Use the blue buttons to scroll the menu until the pointer is pointing to the appropriate system menu item. Press the green button to select.



1. Battery life:



Note: If Qt has been on charge, disconnect the power supply and/or USB cable for at least 15 seconds to obtain a true value.

Qt Timer will determine the power requirements of the sensors connected and compare this with the charge level of the batteries. The LCD will display:

- Awake: the number of hours Qt Timer could continuously operate without a power supply attached.
- Level: the capacity charge level of the battery.

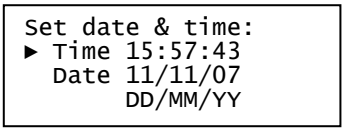
The LCD display will show 'Battery is charging' if power is being supplied to Qt Timer (via a power supply or USB connection).

Press the red button to return to the System menu.

Note: Ideally Qt should be stored with at least 40% or more charge. Do not store Qt with its battery fully discharged or with sensors connected. Some reserve charge is needed to retain data and settings in memory.

2. Set date & time:

Data and time are automatically set by the EasySense software (using the settings from your computer's clock). If Qt is not used with the software the date and time can be set on the unit.



- Set date format: Select how you would like the date displayed. Use the blue buttons to scroll through the choice of formats: DD-MM-YY, MM-DD-YY, YYYY-MM-DD until your choice of format is shown. Press to select.
- Set Time: uses a 24 hour clock. Use the blue buttons to scroll the numbers up or down until the correct hour is shown, press to select, the cursor will move onto minutes. Repeat for minutes and then seconds.
- Set Date: day/month/year. Use the blue buttons to scroll the numbers up or down until the correct day is shown, press to select. Repeat for month and then year; press to return to the System menu.

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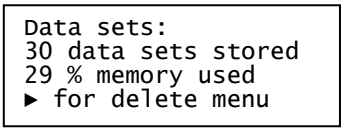
3. Data sets

Data sets stored – Indicates the number of individual data sets stored.
Memory used – Indicates the amount of memory used in storing the captured data as a percentage of the total memory.



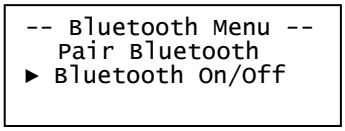
To delete all or some data sets – Press ▶ for the delete menu. Either leave as 'all data sets' or use the blue scroll buttons to choose an individual set of data. Press ▶ to select and then ▶ to confirm your choice. Press ■ to return to Data sets.

Press ■ to return to the System menu.

4. No Bluetooth or Bluetooth

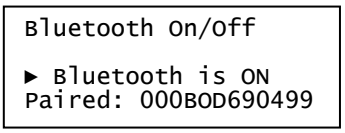
If Bluetooth has been built-in it will show listed as Bluetooth. If not then the System menu will show 'No Bluetooth'.

- Use the blue ▲▼ buttons to scroll until the pointer is pointing to the appropriate menu item. Press the green ▶ button to select.



Note: If you have already 'paired' your logger do **not** select 'Pair Bluetooth' – this action will delete any existing pairing and you will have to complete the Bluetooth pairing process again.

Bluetooth On/Off – use to switch Bluetooth either on or off. Use the blue ▲▼ buttons to scroll between ON and OFF. Pressing the green ▶ button to select your choice and return to the System menu.



Note: If the only option available is OFF, then the unit is not currently paired with a computer.

The number shown as 'paired' is the MAC address for the Bluetooth device that it is currently paired with.

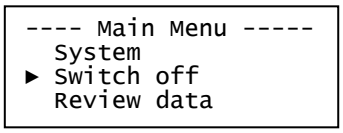
When Qt is awake and Bluetooth is On, the blue indicator LED at the back of the unit will be lit.

Pair Bluetooth
Selecting 'Pair Bluetooth' will delete any existing pairing and will initiate the Bluetooth pairing process. See page 28 for instructions on the pairing process.

See Appendix 2 on page 27 for information on using Qt with Bluetooth.

Switch off

Use this option to send Qt directly into low power (sleep mode), even when a supply of power is attached.



Use the blue ▲▼ buttons to scroll the menu until the pointer is pointing at Switch off in the Main Menu. Press the green ▶ button to select.

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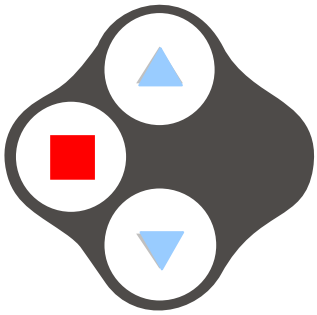
Press any button to 'wake up' the unit.

Note: If Qt is operating on battery power you do not have to use this option to switch the unit off, after a period of inactivity the logger will auto power down.

Technical Information

Hard Reset

Should **EASY**SENSE Qt Timer fail to respond to the computer or a button press, carry out a HARD RESET.



1. If necessary attach **EASY**SENSE Qt to mains power.
2. Hold the red square and both blue triangle buttons down (at the same time) for a second and then release.

If the hard reset has been done correctly, the LCD will display **EASY**SENSE Qt and the version number of its operating system before returning to the main menu

If Qt still fails to respond, please contact Data Harvest.

Note: A Hard Reset does **not** erase any stored data sets but if a recording is interrupted by a reset, then the data being captured will not be stored.

Powering Qt Timer

Qt Timer can be powered by:

1. Using the mains power supply provided
2. The USB port (when connected)
3. Its internal batteries (when charged)

The power light on Qt will only light when the unit is accepting power from a mains power supply or via the USB cable.

Mains Power

The power supply unit supplied is used to power Qt and to recharge its internal batteries in preparation for logging data away from the computer. Connect the mains power adapter to the POWER socket on the side of the unit.

Power supply specifications are a 5V DC mains adaptor, able to supply able to supply 500 to 1000 mA, with a positive centre and negative outer pin.

Batteries

Qt is fitted with a rechargeable lithium ion battery pack. Whenever Qt is connected to its mains power supply or the USB port on the computer, it will automatically re-charge the batteries. A full charge will take approximately 12 hours.

Notes:

- The USB drivers must be installed on the computer before charging will begin. The USB chip will be powered by a USB port, so the drivers can be installed even if the logger's battery is discharged.

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- If the computer is switched off or in sleep mode, charging via the USB port will stop.
- **EASY**SENSE Qt can only be connected directly to a computers USB port or by using a **powered** USB hub. It will not work with an unpowered hub (Qt requires an output current of 500 mA).

Lithium ion batteries are 'memory-free' and prefer a partial rather than a full discharge. Constant partial discharges with frequent recharges will not cause any harm. Frequent full discharges should be avoided whenever possible.

Ideally **EASY**SENSE Qt should be stored at about **40% or more** charge. Do **not** store Qt with its battery fully discharged. Even when turned off (sleep), Qt will use a small amount of current, and the battery will slowly discharge. If Qt is to be stored for lengthy periods without use then it's a good idea to recharge the batteries every 6 – 8 weeks.

The speed at which a lithium ion battery will age is governed by both its storage temperature (preferably less than 40ºC) and state-of-charge. Eventually the battery pack will no longer deliver the stored energy and will need to be replaced. A fully charged battery that looses its charge quickly or a battery with symptoms of swelling or physical damage will demonstrate the need for replacement. When this happens contact Data Harvest and request a battery replacement pack for **EASY**SENSE Qt – Product No. 5007.

The lithium batteries in Qt operate best at near room temperature, between 10 and 30˚C, (50 to 86˚F) but can be used at any temperature between 0 to 40˚C (32 to 104˚F). If Qt has been left in the cold, let it warm to near room temperature before waking it from sleep.

Specifications

4 x 20 Character LCD Display
USB communication V1.1 & V2.0 compatible
Memory Capacity: 256 kB
Digital timing from A to B: 4 µs resolution
Resolution up to 5 decimal places
Firmware upgradeable
Operating range: 0 - 40°C and 0 to 95% RH (non-condensing).
Power supply specifications: 5V DC mains adaptor, able to supply 500 to 1000 mA,, with a positive centre and negative outer pin.

Bluetooth functionality (if fitted):
Compatible with a Bluetooth V1.1 or later devices
Operating range: 10 metre (33 Feet) radius indoors

Language

Q Timer may have a language choice. If so, the options available will display during a hard reset.

- Hold the red square and both blue triangle buttons down (at the same time) for a second and then release.
- After the operating system number the screen will show the language options (if any) before returning to the main menu. The pointer will indicate the current language selected.

- If you wish to alter the choice use the blue buttons to scroll the pointer until it is pointing at the preferred language, which Qt will automatically employ.

Care & Maintenance

- Clean with a damp cloth, do not immerse in water or detergent. Qt is not waterproof.
- Qt is suitable for use in an operating range of 0 – 40˚C and 0 to 95% RH (non-condensing).
- If Qt has been left in the cold, let it warm to near room temperature before waking it from sleep.
- Do not expose to direct sunlight for extended periods of time.
- Do not expose to temperatures greater than 60˚C, e.g. near a heater or inside a car in hot weather.
- Do **not** store Qt Timer with its battery fully discharged. Ideally Qt should be stored at about **40% or more** state-of-charge.

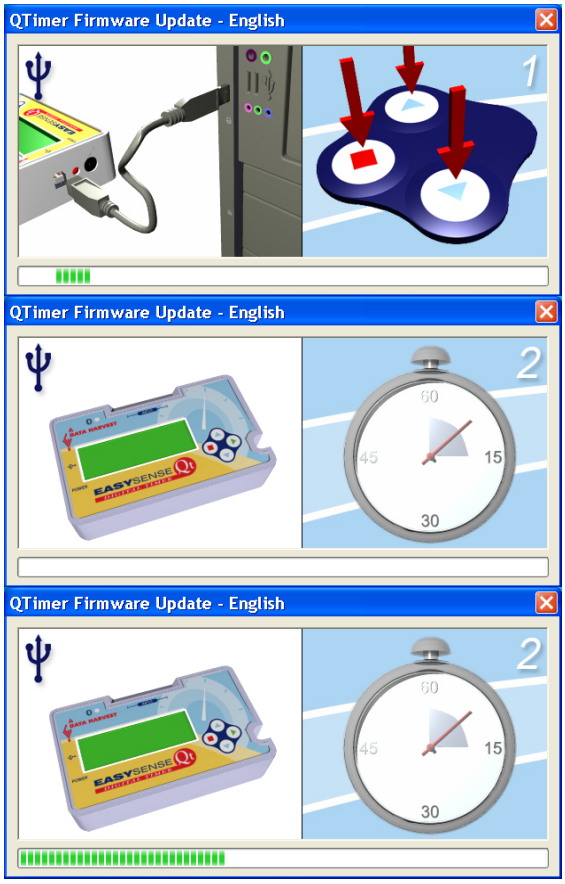
Updating Qt Timer's firmware

Occasionally Data Harvest may release updated firmware, which will contain improvements or new features. These updates will be made available from the Data Harvest website. To update the firmware of Qt Timer:

Step 1. Copy the Qt's Timer English Firmware Update onto the hard disc of your computer.

Step 2. Connect Qt to the computer using the USB cable.

Note for Bluetooth users: Bluetooth must be OFF.

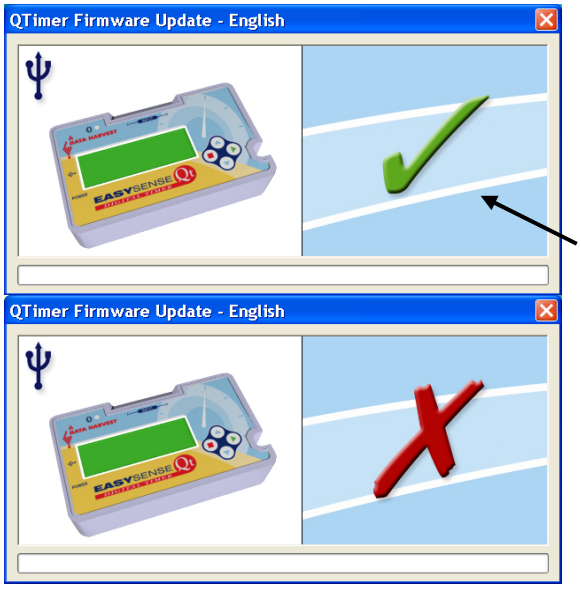


Step 3. Carry out a HARD RESET on Qt by holding down the red and both blue buttons for a second.

Wait for a few seconds.

A progress bar will indicate Qt is being programmed.

WARNING: Do **not** disconnect Qt during this re-programming stage or it may be seriously damaged.



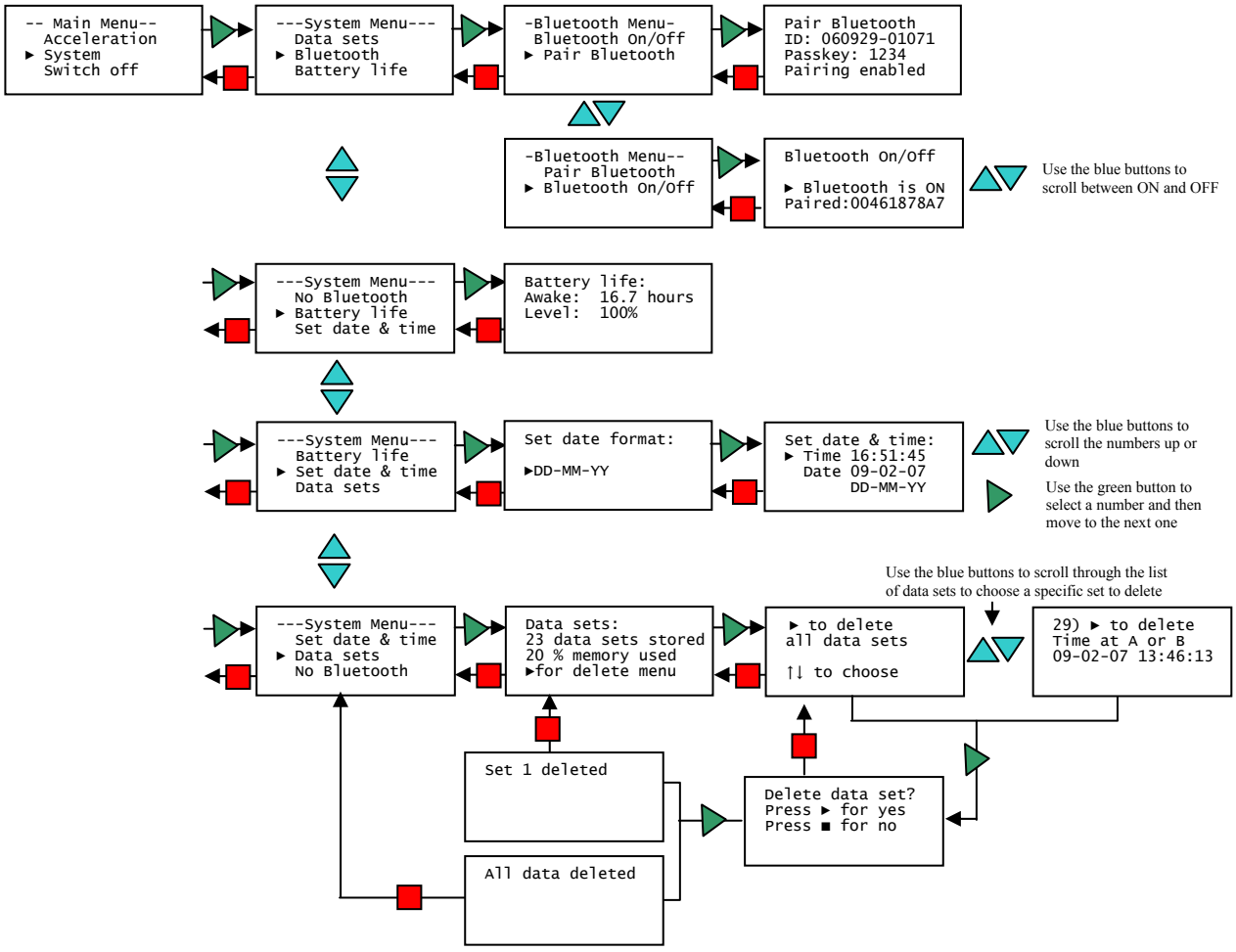
A **tick** will indicate if the process was successful. Disconnect the Qt.

If you wish to repeat these processes, connect another logger, and click in the update window to return to the start screen (step 2).

A **cross** will indicate that an error occurred. Click in the update window to go back to start screen (step 2) and try again.

Step 4. Exit the program.

Appendix 1: System menu



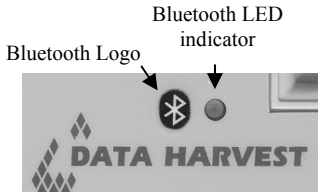
Appendix 2: Using Qt Timer with Bluetooth

Requirements

1) Your Qt Timer must have a built in Bluetooth module. If it has there will be:

- A Bluetooth logo (above the Data Harvest logo) on the top panel of the logger.
- Bluetooth listed as a menu item in the System menu (from the Main Menu select System).

  Note: If Bluetooth is not fitted then it will list 'No Bluetooth'.



2) Your Desktop or Laptop computer must be Bluetooth enabled. Bluetooth can be added to a computer by using an external adapter that plugs into a spare USB socket.

3) Your PC should be running Windows XP with Service Pack 2 or higher, which includes its own Bluetooth stack software.

General Information

With Bluetooth technology Qt can 'talk' wirelessly to your computer over a distance of up to 10 metres.

Bluetooth will allow only one Qt Timer to talk to one computer at a time. It is not possible to connect Qt simultaneously to multiple computers.

Once paired Qt will store the electronic identity of the Bluetooth device it was paired with, so it can automatically re-connect to the adapter/computer in the future. It will only store the electronic identity of the device it was last paired with.

If you use a Bluetooth USB adapter then Windows XP will install a new set of drivers each time the adapter is plugged into a new USB port. Each Bluetooth USB adapter identifies itself to the computer as a different device so if you plug another adapter into the same USB port then another set of drivers will be installed. The result of either of these actions is a different COM port setting, which will need to be selected from Interface in the File menu of the EasySense software. For these reasons we strongly recommend that a Qt Timer is always used with the same computer, with the same Bluetooth USB adapter connected to the same USB port on the computer.

Note: You may find it useful to number the computer, Qt, Bluetooth adapter and USB port to identify this combination.

Power

Power consumption is **increased** when Bluetooth is on. To check the number of hours Qt could operate without a power supply attached, make sure Bluetooth is on (blue LED lit), that the sensors to be used are connected, and then select Battery life from the System menu.

If Qt is connected to a mains power supply it will not auto switch off and will stay 'awake' at all times.

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If Qt is operating on battery power with Bluetooth on and is not being used (e.g. not logging data, no buttons being pressed), it will automatically switch itself **off** after five minutes (LCD display blank).

If Qt is off (LCD display blank), Bluetooth communication will cease and connection to the EasySense software will be lost. Press any button to wake up the logger before re-establishing connection.

Installing the Bluetooth USB adapter

Microsoft's Service Pack 2 for Windows XP includes its own Bluetooth stack. To install the Bluetooth USB adapter, simply plug the adapter into a spare USB port (preferably a port that the adapter can be left in). Windows will identify the adapter and load the drivers; the process is automatic and requires no input from the user.

Qt is a Bluetooth 1.1 Standard device, and as such should operate with any Version 1.1 or higher Bluetooth adapters/dongles; however Data Harvest cannot guarantee full operation with all makes of adapter.

Initial use (pairing Qt to the PC)

To prevent Qt switching off during the pairing process we recommend connecting to its mains power supply.

To use Qt with a PC via Bluetooth, an initial pairing must be created. This pairing allows the logger to automatically re-connect to the PC in the future, and ensures that it will not talk to or interfere with any other Bluetooth to PC connections running nearby.

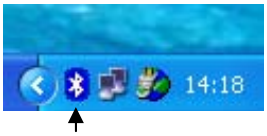
Qt will attempt to pair with another Bluetooth device for 2 minutes, giving time for the PC Bluetooth services to be started

Note: The following screen shots are based on a PC using the standard Windows XP Bluetooth software stack. Other Bluetooth adapters/dongles may use different software, and screens may appear different. However, the principles described for 'discovery & pairing' are the same.

This initial set up is a three step process:

Step 1: Discover devices

Connect the Bluetooth USB adapter to the PC.
Open the Bluetooth Devices manager either via Control Panel from the Start menu or the Bluetooth device icon on the taskbar.

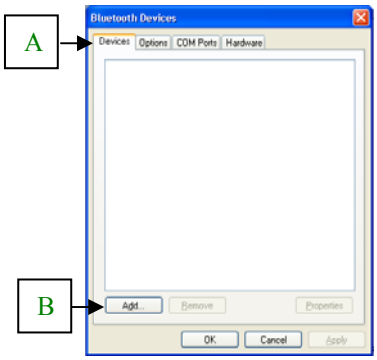


Bluetooth icon

Step 2: Pair the devices

1. Select the **Devices** tab (A).

2. Click **Add** (B) and the 'Add Bluetooth Device Wizard' will launch.



On Qt**:**

3. Connect Qt to its mains power supply.

4. Use the blue ▲▼ buttons to scroll the main menu until the pointer is pointing at **System**. Press the green ▶ button to select.

```
---- Main Menu ----
  Time & Motion
▶ System
  Switch off
```

5. Use the blue ▲▼ buttons to scroll the menu until the pointer is pointing at **Bluetooth**. Press the green ▶ button to select.

```
---- System Menu ----
  Data sets
▶ Bluetooth
  Battery life
```

6. Use the blue ▲▼ buttons to scroll the menu until the pointer is pointing at **Pair Bluetooth**. Press the green ▶ button to select.

```
-- Bluetooth Menu --
  Bluetooth On/Off
▶ Pair Bluetooth
```

The LCD screen will show;

- ID: this is Qt's serial number, which will be used to identify the logger in the new devices list e.g. 060131 - 01256.
- Passkey: All Qt loggers have a passkey of 1234. The passkey is not configurable and is fixed at manufacture.
- Pairing message: displays the point in the pairing process that Qt has reached. The messages are:

  Powered/Discovering – this is shown when the Bluetooth module in Qt is initialised.
  Pairing enabled - Qt is transmitting pairing information that can be received by a Bluetooth receiver (e.g. the Bluetooth USB adapter or the PC).
  Paired: xxxxxxxxxx (e.g. 000B0D6904AE) – the pairing between Qt and the receiver is complete; the number displayed is the Mac address for the Bluetooth device that it is currently paired with.

On the computer

7. Tick the box on the Wizard to indicate 'My device is set up and ready to be found' (C).

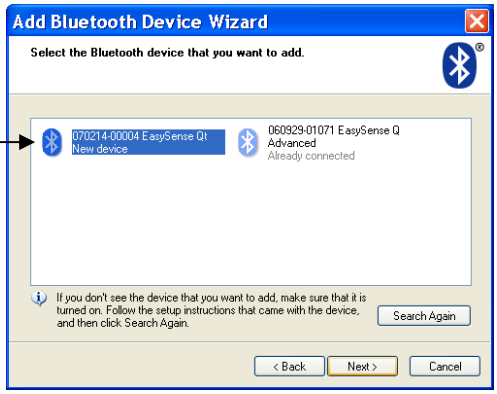
8. Click on Next to begin

Add Bluetooth Device Wizard
Welcome to the Add Bluetooth Device Wizard
Before proceeding, refer to the "Bluetooth" section of the device documentation. Then set up your device so that your computer can find it:
- Turn it on
- Make it discoverable (visible)
- Give it a name (optional)
- Press the button on the bottom of the device (keyboards and mice only)
My device is set up and ready to be found.
(C)
Add only Bluetooth devices that you trust.
< Back
Next >
Cancel

9. Your PC will search for any Bluetooth devices that are discoverable and within range.

10. Click on the Qt that is going to be paired (D).

11. Click on Next.


Add Bluetooth Device Wizard
Select the Bluetooth device that you want to add.
(D)
070214-00004 EasySense Qt
New device
060929-01071 EasySense Q
Advanced
Already connected
If you don't see the device that you want to add, make sure that it is turned on. Follow the setup instructions that came with the device, and then click Search Again.
Search Again
< Back
Next >
Cancel

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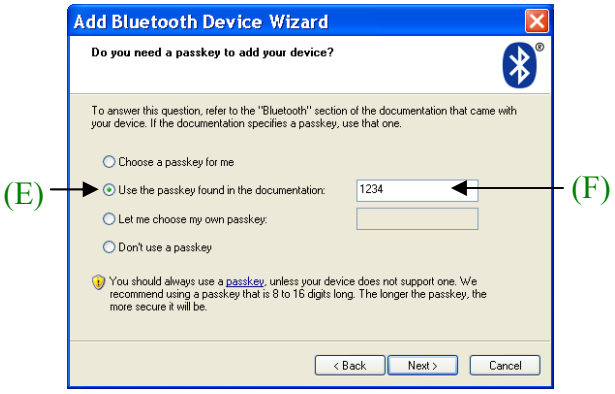
Notes:

- Qt is identified by its serial number, which is written on the base of the unit and shown on the LCD display (when Pair Bluetooth is selected).
- Qt will attempt to pair with Bluetooth device for 2 minutes. If you have taken more than 2 minutes Qt may show a 'Pairing failed' message. Press the red button on Qt, to exit the Pair Bluetooth menu and then press the green button to select again. Click on Search Again in the Device Wizard.

12. You will then be asked if a Passkey is required. Click on "Use the passkey found in the documentation" (E).

13. Type 1234 in the passkey (F).

14. Click Next.


Add Bluetooth Device Wizard
Do you need a passkey to add your device?
To answer this question, refer to the "Bluetooth" section of the documentation that came with your device. If the documentation specifies a passkey, use that one.
Choose a passkey for me
Use the passkey found in the documentation:
1234
Let me choose my own passkey:
Don't use a passkey
You should always use a passkey, unless your device does not support one. We recommend using a passkey that is 8 to 16 digits long. The longer the passkey, the more secure it will be.
< Back
Next >
Cancel
(E)
(F)

There will be short pause as passkey information is exchanged between the computer and Qt; the screen will show a check list for each stage. When the exchange has taken place and is successful the final page of the wizard will be shown.

Windows XP will assign COM ports. Qt will communicate with the computer (and therefore the EasySense software) over the 'Outgoing COM port. Make a note of the '**Outgoing COM port'** number (G)**.**

Add Bluetooth Device Wizard
Completing the Add Bluetooth Device Wizard
The Bluetooth device was successfully connected to your computer. Your computer and the device can communicate whenever they are near each other.
These are the COM (serial) ports assigned to your device.
Outgoing COM port: COM19
Incoming COM port: COM20
Learn more about Bluetooth COM ports.
To close this wizard, click Finish.
< Back
Finish
Cancel
(G)

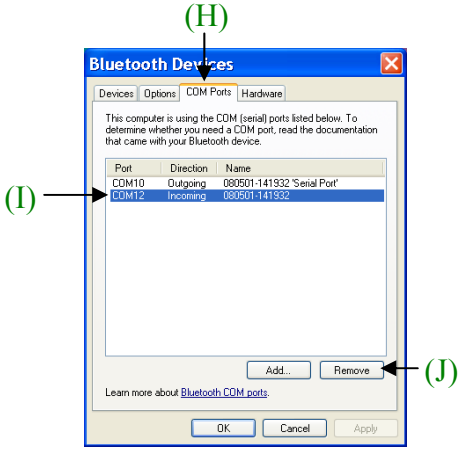
If the Outgoing COM port number is not shown in this window, it will need to be added manually – see page 34.

The LCD screen on Qt will show the electronic identity number of the Bluetooth receiver it has paired with. Bluetooth will be automatically switched on (blue LED will be lit).

```
Pair Bluetooth
ID: 060929-01071
Passkey: 1234
Paired: 00461878A78
```

15. Click on Finish to close the wizard.

16. To prevent the Incoming COM port being shown in the Interface connection's drop-down menu, select the COM Ports tab (H), the **Incoming** COM port entry (I) and click on Remove (J).



17. Press the red button on Qt twice to return to the Main menu.

Step 3: Establishing communication

1. Open the EasySense program.

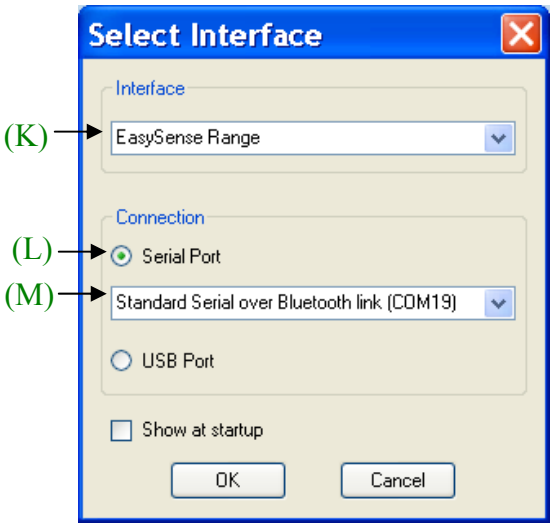
2. If this is the first time the EasySense program has been opened an interface window will open (or if not and a communication error message appears, click on Interface).

3. Select the Interface as EasySense Range (K).

4. Select **Serial port** (L) and then the outgoing serial (COM) port link from the drop-down list (M).

5. Click on OK. The program will save your selection so it will be automatically configured when next used.

6. When a connection is established the Home window will open.



Use after the initial set up

- If the display is turned off, press any button to wake up Qt. If the blue LED doesn't start to flash check that Bluetooth is On (System menu ► Bluetooth menu ► Bluetooth On/Off).

  Note: Do **not** select 'Pair Bluetooth' – this action will delete any existing pairing and you will have to complete the Bluetooth pairing process again.

- Open the EasySense software. As long as Qt is being used with the same computer / Bluetooth USB adapter, connected to the same USB port, communication will be established and the Home screen will open.

If Qt is operating on battery power with Bluetooth on and is not being used, it will automatically switch itself **off** after five minutes (LCD display blank). If Qt is off, Bluetooth communication will cease and connection to the EasySense software will be lost. Press any button to wake up Qt before re-establishing connection.

Note: If Qt is connected to a mains power supply it will stay 'awake' at all times.

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Trouble shooting

Before reporting faults please attempt a **HARD RESET**t.

1. If necessary attach to power.
2. Hold down the red square and both blue triangle buttons and keep them all held down for 1 second and then release.

If the hard reset has been done correctly, the LCD will momentarily display Qt and the version number of its operating system before returning to the main menu.

Technical support

If you are experiencing a problem, please contact the Technical Support department at Data Harvest. Please provide details of:

- The computer platform it is being used with.
- The software version number
- A description of the problem being encountered

If possible, telephone from a location where you can operate Qt with the computer.

Problem Solving

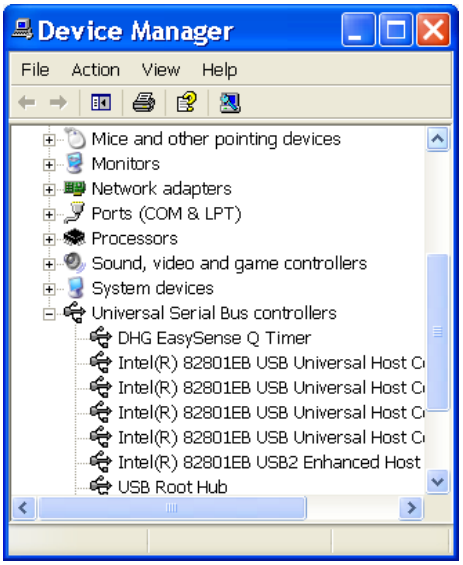
Question 1: The LCD screen on the logger is blank and when I press a button it doesn't wake it up.

Connect Qt to power and leave on charge for at least 5 minutes then Hard Reset the logger.

*Question 2: I am having a problem establishing a connection between Qt and the EasySense software when connected via a **USB port.***

1. Check the LCD screen on Qt shows the Main Menu.
2. If Bluetooth is fitted check it's switched OFF (the Bluetooth LED should not be lit when the logger is awake).
3. Check that the USB lead is plugged in at each end.
4. Open the EasySense software. Select Interface from the unable to connect message (or from the File menu). Check the interface is set to EasySense Range and that the method of connection is **USB port**.
5. If there is still a problem, check in Device Manager that the USB drivers have installed correctly:
   Windows XP Users: Go to Start→ Control Panel→ (if necessary switch to Classic view) → System→ Hardware tab → Device Manager.
   Vista Users: Go to Start→ Control Panel→ (if necessary switch to Classic view) → Device Manager.

   Check a DHG EasySense Qt Timer is listed in the Universal Serial Bus controller's list.
   If there are any question marks or exclamation marks then the drivers haven't installed correctly. Delete the drivers. Disconnect Qt



from the USB port. Plug back in so the drivers re-install.

*Question 3: I am having a problem establishing a connection between Qt and the EasySense software when connected via **Bluetooth.***

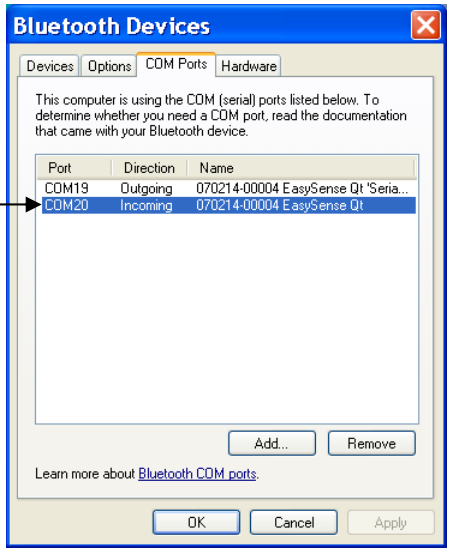
1. Check the LCD screen on Qt shows the Main Menu.
2. If Qt is asleep, press any button to wake up the logger.
3. Check the Bluetooth LED is lit (Bluetooth On). If not, select Bluetooth On/Off from the System menu, and select On.

   Note: If the only option is Off then Bluetooth is not currently paired with a computer/Bluetooth USB adapter. See page 28 for pairing information.

4. If possible connect Qt to main power supply to exclude problems caused a low battery charge level and to prevent the unit going to sleep.
5. Open the EasySense software. Select Interface from the unable to connect message (or from the File menu). Check the interface is set to 'EasySense Range' and the method of connection is **Serial port.** Select the Outgoing Bluetooth link as the COM port from the drop-down list.

   To check the Outgoing COM port number for the Bluetooth device
   - Double click on the Bluetooth Devices icon
   - Select the COM Ports tab.
   - The devices and the virtual Com ports they use will be shown in a list. Identify Qt by its serial number and note its 'Outgoing' COM port number.

If the incoming COM port is listed then to avoid confusion as to which COM port to use in the Interface connection's drop-down menu, select the **Incoming** COM port and click on Remove.



Question 4: I am using Bluetooth but the blue LED on my Qt isn't lit.

If the LCD display is blank press any button to wake up Qt. If the blue LED doesn't light check that Bluetooth is On (System menu ► Bluetooth menu ► Bluetooth On/Off and select On). If the only option is Off then Bluetooth is not currently paired with a computer/Bluetooth USB adapter. Follow the pairing instructions.

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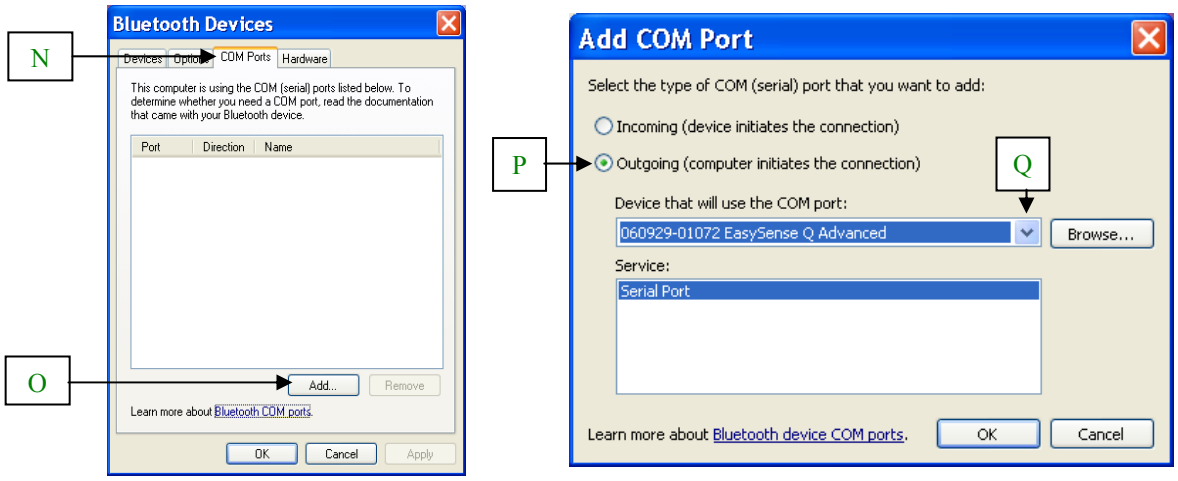
Question 5: The Bluetooth option only shows OFF (so is not currently paired), the Bluetooth Device Wizard already lists Qt as Passkey enabled and when I try to pair I get 'pairing failed'.

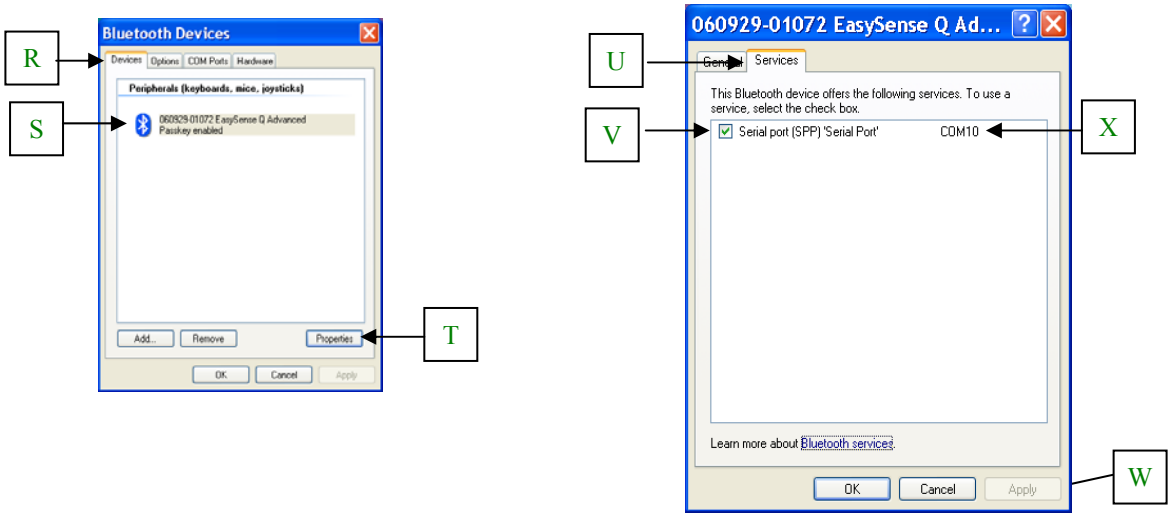
- This can happen if Qt has since been paired with another computer/Bluetooth USB adapter. Press the red button on Qt to exit Pair Bluetooth and clear the current entry.
- Open the Bluetooth Device Manager. Select the **Devices** tab. Select the logger you are using and click on **Remove**.
- Repeat the normal pairing operation. Check there is an Outgoing COM ports entry for your Qt; if not add the COM port manually.

To add the COM port manually
If an Outgoing COM port was not shown as assigned in the Bluetooth Wizard it will need to added manually. There are two methods available:

Method 1: Close the Bluetooth Device Wizard. From the Devices manager select the COM Ports tab (N) and click on Add (O). Click on Outgoing (P), select Qt from the drop-down list of devices (Q) and click on OK.



Method 2: From the Devices manager select the Devices tab (R). Select Qt (S) and then Properties (T). Select the Services tab (U), select the check box next to Serial port (V) and click on Apply (W). When the COM port for the serial port (X) is shown click on OK. Click on the COM ports tab and note the Outgoing COM port number.



Question 6: What do I do when I get a Memory full message?

You will need to free some memory by deleting some or all data sets from Qt's memory using delete in **Data Sets** from the System menu. See page 22 for further details.

Question 7: Will I get a warning if the battery level is low?

When the charge level of the battery is very low (about 10 % or less) a 'Battery low' message will start to appear on the LCD screen. Connect Qt to its power supply or to the USB port on a computer to charge the batteries. Press any button to clear the message.

Note: If the battery low message is ignored, and the charge level drops even further, the logger will display "Recharge battery!" and switch off. Charge the batteries.

Question 8: Do the batteries need to be discharged/ reconditioned?

No, the batteries in Qt are lithium ion and are 'memory-free'. Avoid full discharges when ever possible. Constant partial discharges with frequent recharges will not cause any harm.

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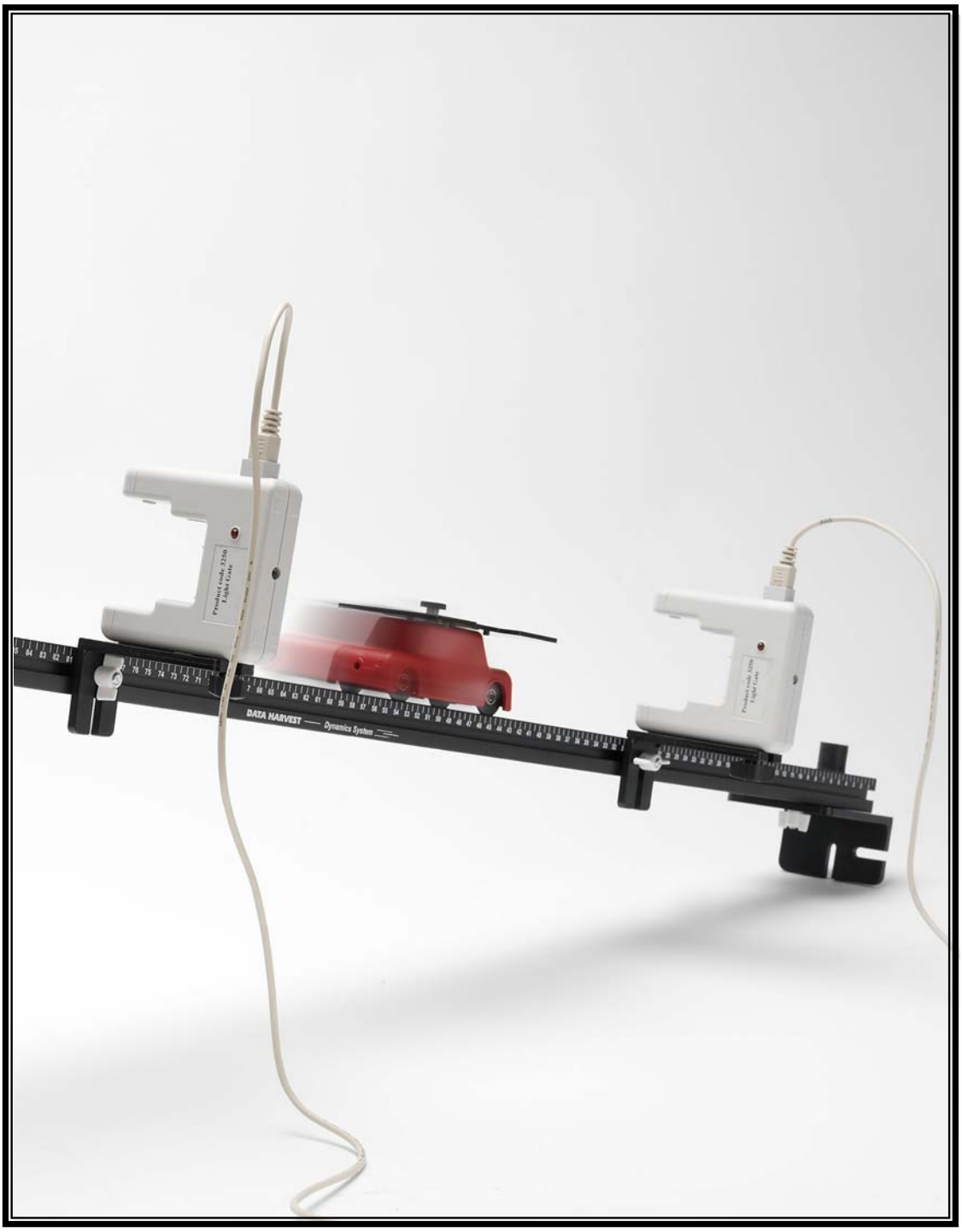
Experiment Guide

(Using Qt as a stand alone timer with the Dynamics system)



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Motion

Teacher's notes for Ms01 to Ms05

Read

Ms01 – 02

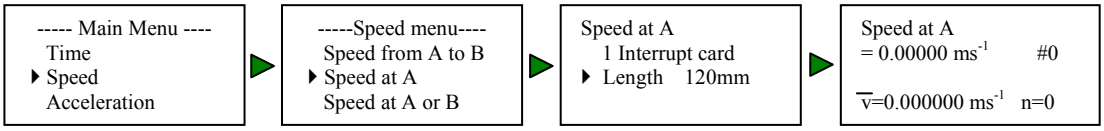
These activities are an introduction to the use of a **single** Light Gate to measure speed or acceleration down a slope. Analysis can be set at a numbers of levels. With more able students it can lead to finding the mathematical relationship between the angle of slope and the speed or acceleration. A fixed starting point is used to create a fair test.

Ms03 - 05

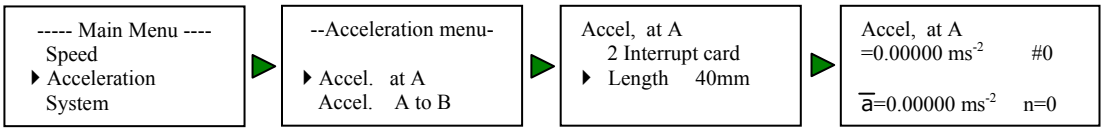
These activities are an introduction to the use of **two** Light Gates to measure speed, velocity or acceleration.

Set up of Qt

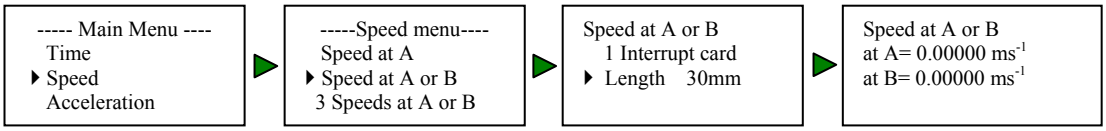
For **Ms01** – Using **one** Light Gate to measure **Speed**



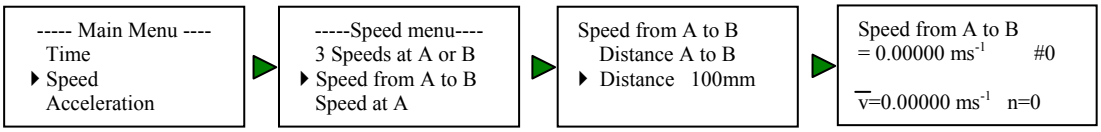
For **Ms02** – Using **one** Light Gate to measure **Acceleration**



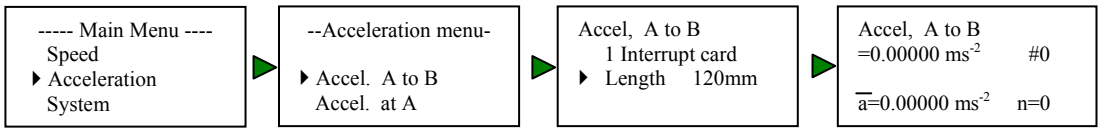
For **Ms03** – Using **two** Light Gates to measure **Speed at A or B**



For **Ms04** – Using **two** Light Gates to measure **Speed (Velocity) from A to B**

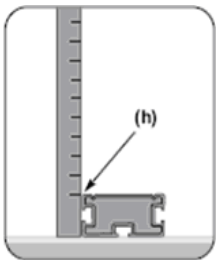


For **Ms05** – Using **two** Light Gates to measure **Acceleration from A to B**



Notes

Do not start with the track set at a large angle. About 2.5˚ is enough. If used with the pillar, fix the track to the 5 cm mark (Angle = height (h) on scale divided by 2 when the end of the track is supported by the large bracket).



Fit a crash box to the end of the track. As the angle of the slope increases so will the speed of the cart.

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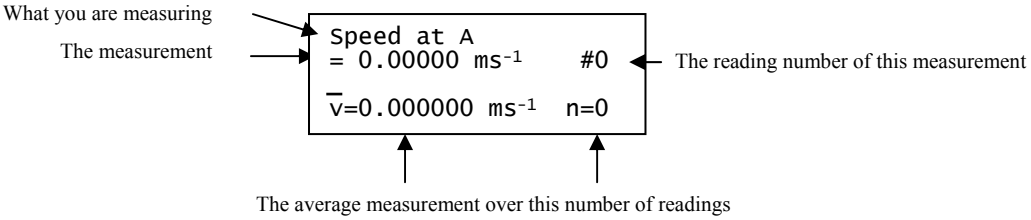
Make sure the interrupt card is correctly positioned. There are locating pegs on the card and locating holes on the body of the cart to make this easier. The attachment screw should only be finger tight.

Check that the cart is running well by testing it along a horizontal track. If it is not running freely lubricate the bearings of the cart with WD40 (a light silicon based lubricant) or alcohol.

Results and analysis


What you are measuring
The measurement
Speed at A
= 0.00000 ms-1 #0
v=0.000000 ms-1 n=0
The reading number of this measurement
The average measurement over this number of readings

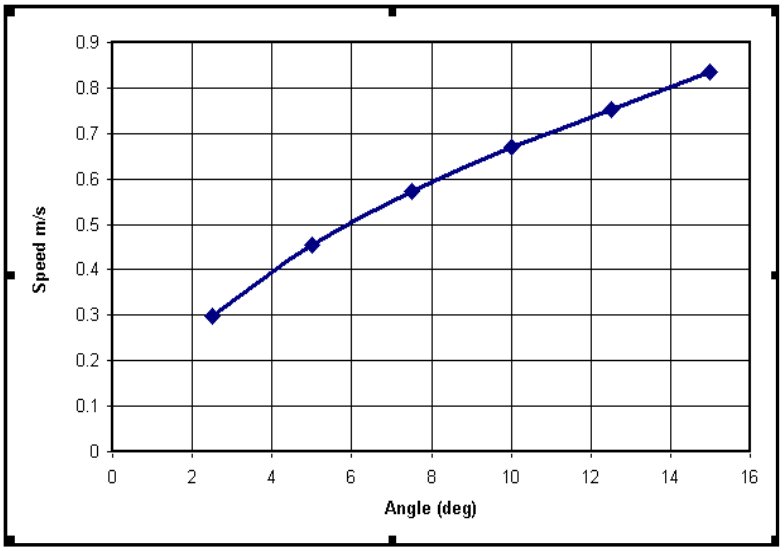
The average measurement can be read from the bottom line of the display. You can scroll back through the values of speed/acceleration by using the ▲▼ buttons on Qt.

If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment e.g. with the angle of the slope.

To review a data set on Qt press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

Results for Ms01 - Speed down a slope

Height of track (cm)	Angle (degrees)	Speed (m/s)
5	2.5	0.29717
10	5	0.45492
15	7.5	0.57167
20	10	0.66934
25	12.5	0.75330
30	15	0.83393

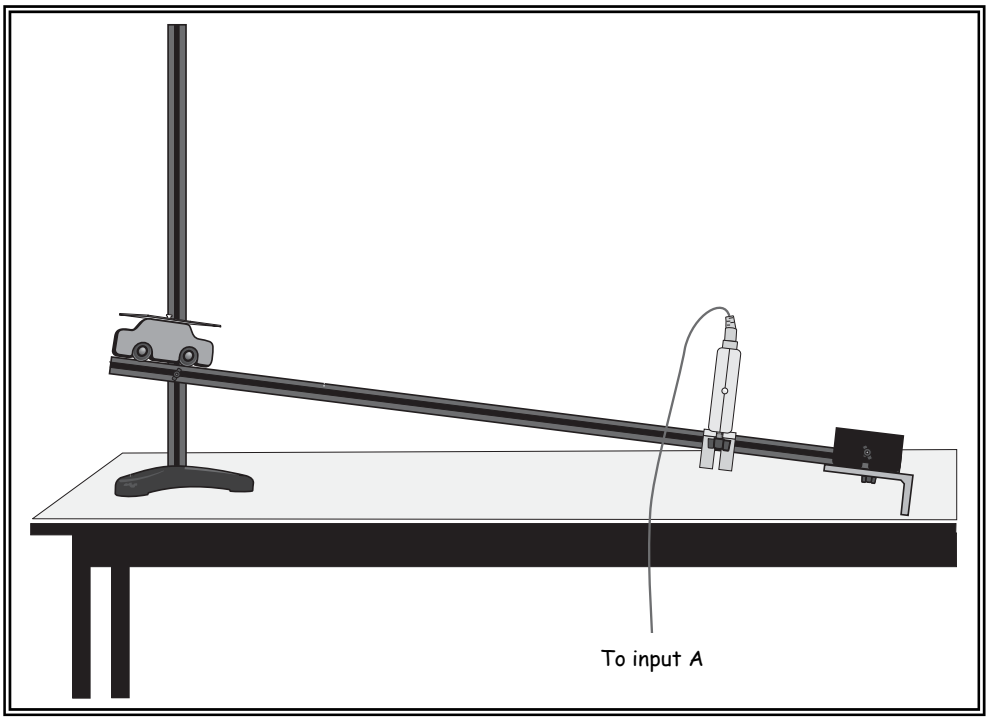


The data shown as an Excel graph.

Ms01 – Measuring speed down a slope using one Light Gate

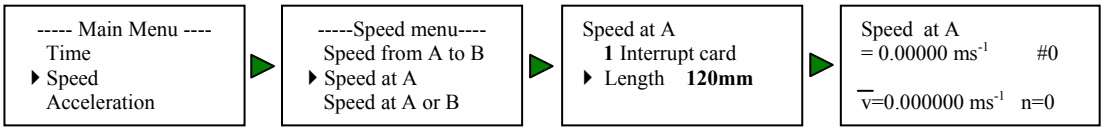
What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate
3. Dynamics system track and pillar
4. A thin bracket to attach the Light Gate
5. Dynamics cart with single interrupt card
6. Crash box fitted to the end of the track



What you need to do

1. Assemble the Dynamics system as shown in the diagram. Note the height of the track.
2. Fit a crash box at the bottom of the track. Mark a start line on the track for the release of the cart.
3. Position the Light Gate approximately 20 cm from the top of the track and connect to input A on Qt.
4. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gate.
5. Set up Qt to record Speed at A with 1 interrupt card with a length of 120 mm:



6. Place the cart in the start position at the top of the track and release the cart.
7. The speed will be displayed on the second line of Qt's display. Take the cart back to its start position and repeat two more times. The average speed is displayed on the

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bottom line of the display. Note the average speed, current height and angle of slope in a results table.

8. Press the red ■ button to stop.
9. To give the data set a name, press ▲ and scroll to **Name data set**. Select text or numbers to be used as the name, press ► to select as appropriate. Press ■ to finish
10. Press ▼ to scroll to **Repeat experiment** and press ► to select.
11. Repeat with the track at five more heights/angles. Note the average speed for the three runs and the angle of the slope in a results table.

Note: If the track is used with the pillar start at the 5 cm mark and increase the height by 5 cm each time. Angle = height on scale divided by 2 when the end of the track is supported by the large bracket (so a rise of 5 cm will give an increase in slope of about 2.5°).

Analysing your results

- Enter your results in a table like the one below:-

Height of track (cm)	Angle of slope (°)	Average speed (m/s^{-1})

- Draw a graph of angle vs. average speed.

Questions

1. How did the angle of the slope alter the speed?
2. Why did you need to start from the same position each time?

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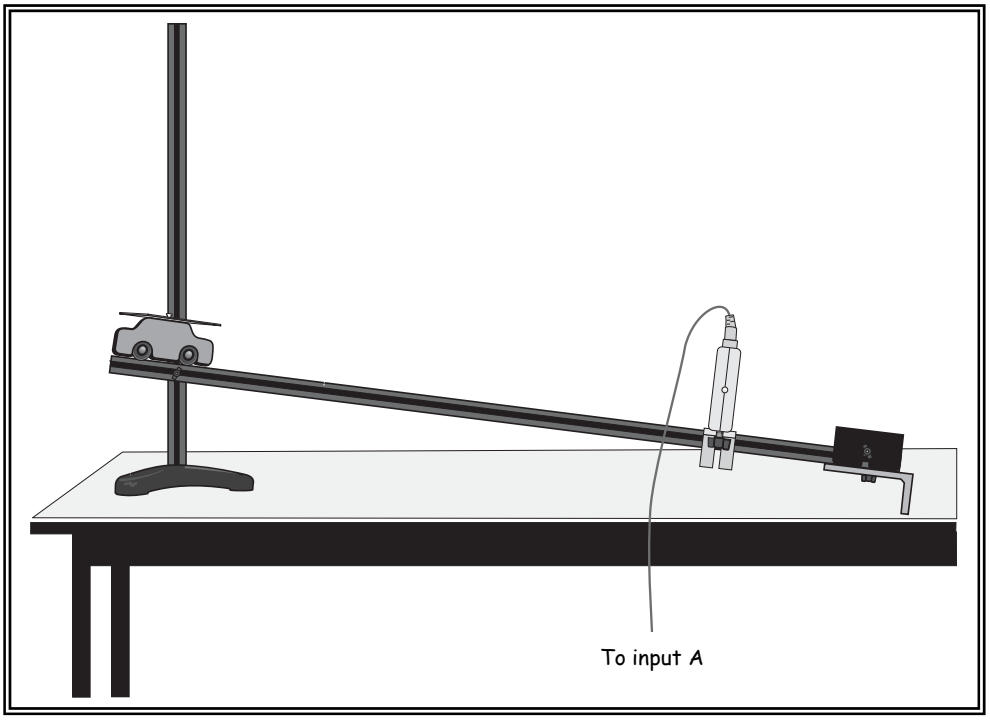
Ms02 – Measuring acceleration down a slope using one Light Gate

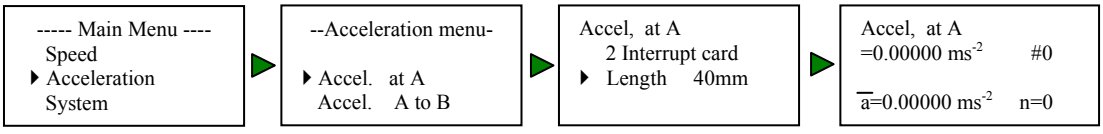
What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate
3. Dynamics system track and pillar
4. A thin bracket to attach the Light Gate.
5. Dynamics cart with double interrupt card
6. Crash box fitted to the end of the track



What you need to do

1. Assemble the Dynamics system as shown in the diagram. Note the height of the track or angle of the slope.
2. Fit a crash box at the bottom of the track. Mark a start line for the release of the cart.
3. Position the Light Gate approximately 20 cm from the top of the track and connect to input A on Qt.
4. Fit the interrupt card to the cart so the **double** interrupt edge will pass through the Light Gate.
5. Set up Qt to record **Acceleration at A** with 2 interrupt card with a length of 40 mm:



6. Place the cart in the start position at the top of the track and release the cart.
7. The acceleration will be displayed on the second line of Qt's display. Take the cart back to its start position and repeat two more times. The average acceleration is displayed on the bottom line of the display. Note the average acceleration, current height and angle of slope in a results table.
8. Press the red ■ button to stop.
9. To give the data set a name, press ▲ and scroll to Name data set. Select text or numbers to be used as the name, press ► to select as appropriate. Press ■ to finish
10. Press ▼to scroll to Repeat experiment and press ► to select.
11. Repeat with the track at five more heights/angles. Note the average acceleration for the three runs and the angle of the slope in a results table.

Note: If the track is used with the pillar start at the 5 cm mark and increase the height by 5 cm each time. Angle = height on scale divided by 2 when the end of the track is supported by the large bracket (so a rise of 5 cm will give an increase in slope of about 2.5°).

Analysing your results

- Enter your results in a table like the one below:-

Height of track (cm)	Angle of slope (°)	Average acceleration (m/s^{-2})

- Draw a graph of angle vs. average acceleration.

Questions

1. How did the angle of the slope alter the acceleration?
2. Why did you need to start from the same position each time?

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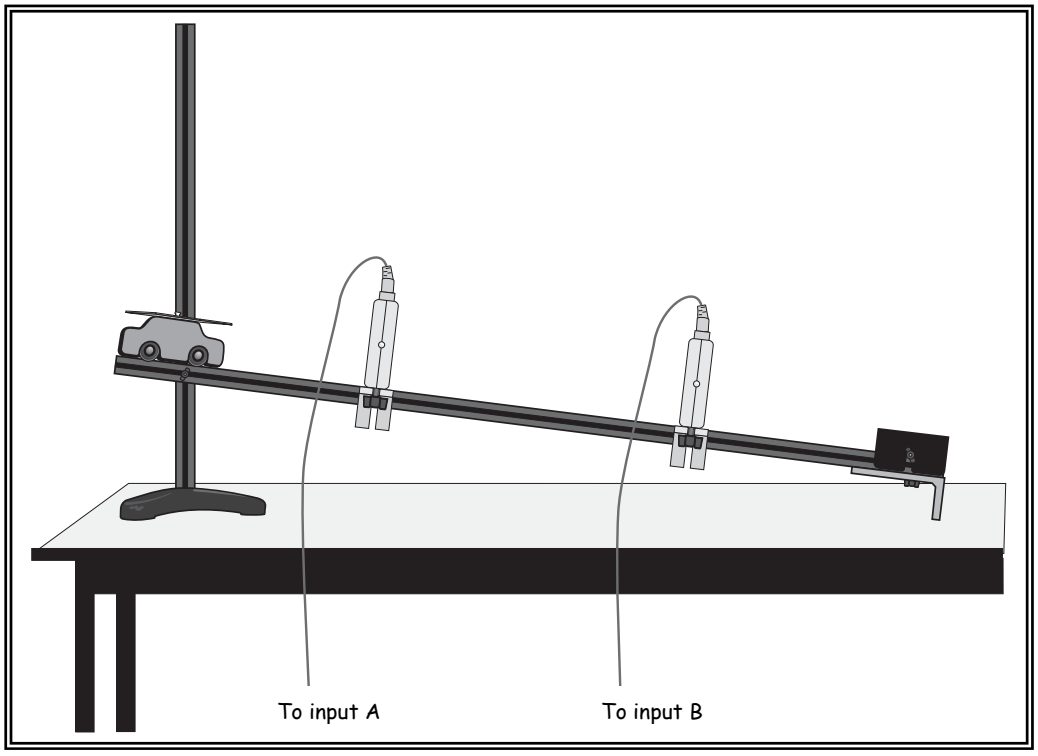
Ms03 - Measuring speed at A or B down a slope using two Light Gates

What you need

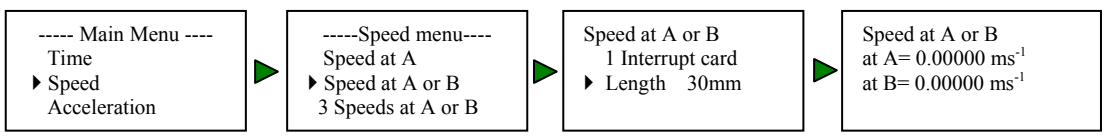
1. An Qt Digital Timer
2. 2 Smart Q Light Gates
3. Dynamics system track and pillar
4. 2 thin brackets to attach the Light Gates
5. Dynamics cart with single interrupt card
6. Crash box fitted to the end of the track



Note: The cart must go through the Light Gate connected to input A first.

What you need to do

1. Assemble the Dynamics system as shown in the diagram. Note the height of the track or the angle of the slope.
2. Fit a crash box at the bottom of the track. Mark a start line on the track for the release of the cart.
3. Position the two Light Gates at approximately the 90 and 40 cm marks on the track. Connect the Light Gate at the 90 cm mark to input A and the Gate at the 40 cm mark to input B on Qt.
4. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gate.
5. Set up Qt to record **Speed at A or B** with 1 interrupt card with a length of 120 mm:



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6. Place the cart in the start position at the top of the track and release the cart.
7. The speed at A and at B will be displayed on Qt's display. Note the values in a results table like the one below. Take the cart back to its start position and repeat two more times.
8. Repeat with the track at five more heights/angles.

Note: If the track is used with the pillar start at the 5 cm mark and increase the height by 5 cm each time. Angle = height on scale divided by 2 when the end of the track is supported by the large bracket (so a rise of 5 cm will give an increase in slope of about 2.5°).

Analysing your results

- Calculate the average speed at A and at B for each angle of slope.

Height of track (cm)	Angle of slope (°)	Speed at A (m/s^{-1})	Average speed at A (m/s^{-1})	Speed at B (m/s^{-1})	Average speed at B (m/s^{-1})
		1.		1.	
		2.		2.	
		3.	=	3.	=
		1.		1.	
		2.		2.	
		3.	=	3.	=
		1.		1.	
		2.		2.	
		3.	=	3.	=
		1.		1.	
		2.		2.	
		3.	=	3.	=
		1.		1.	
		2.		2.	
		3.	=	3.	=
		1.		1.	
		2.		2.	
		3.	=	3.	=

- Investigate the speed at A and then B as the slope angle increases.

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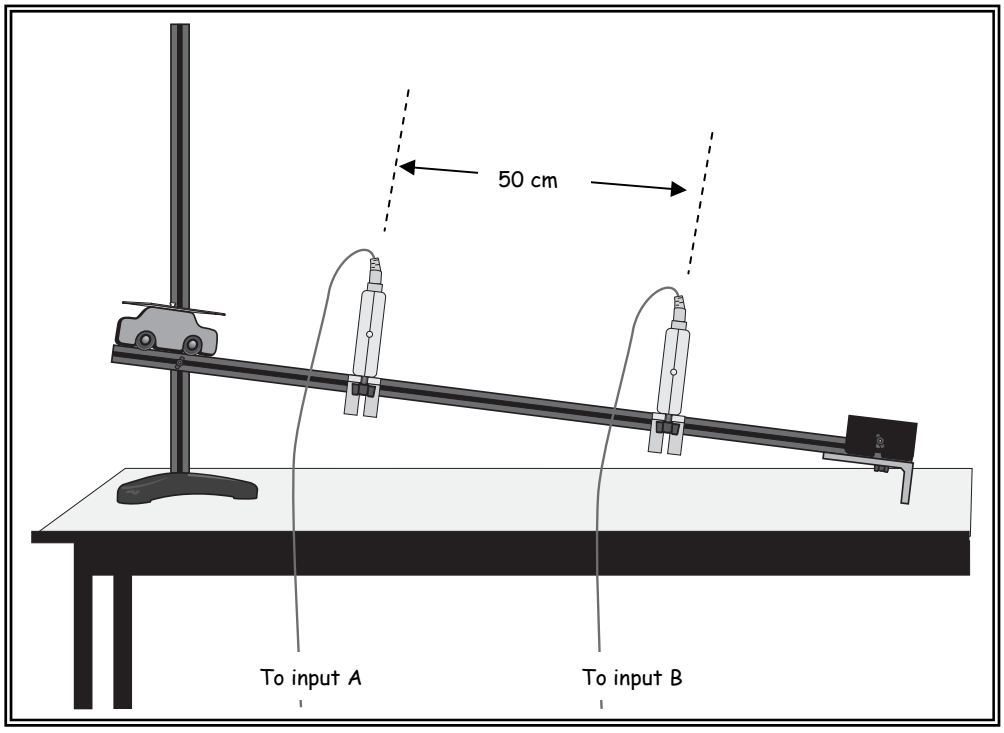
Ms04 - Measuring velocity from A to B down a slope using two Light Gates

What you need

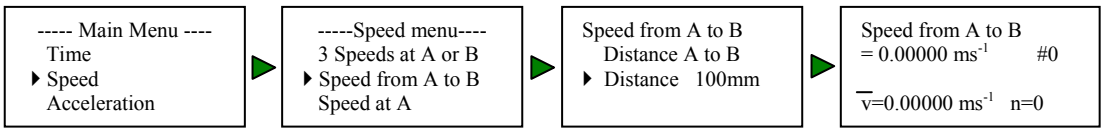
1. A Qt Digital Timer
2. 2 Smart Q Light Gates
3. Dynamics system track and pillar
4. 2 thin brackets to attach the Light Gates
5. Dynamics cart with single interrupt card
6. Crash box fitted to the end of the track



Note: The cart must go through the Light Gate connected to input A first.

What you need to do

1. Assemble the Dynamics system as shown in the diagram. Note the height of the track or the angle of slope.
2. Fit a crash box at the bottom of the track. Mark a start line on the track for the release of the cart.
3. Position the two Light Gates at the 90 and 40 cm marks on the track. Adjust so the distance between two Light Gates is 50 cm (500 mm). Connect the Light Gate at the near 90 cm mark to input A and the Gate at the near 40 cm mark to input B on Qt.
4. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gate.
5. Set up Qt to record **Speed from A to B** with distance of 500 mm between the Gates:



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6. Place the cart in the start position at the top of the track and release the cart.
7. The speed will be displayed on the second line of Qt's display. Take the cart back to its start position and repeat two more times. The average speed is displayed on the bottom line of Qt's display. Note the average speed, current height and angle of slope in a results table.
8. Press the red ■ button to stop.
9. To give the data set a name, press ▲and scroll to **Name data set**. Select text or numbers to be used as the name, press ► to select as appropriate. Press ■ to finish
10. Press ▼to scroll to **Repeat experiment** and press ► to select.
11. Repeat with the track at five more heights/angles. Note the average speed for the three runs and the angle of the slope in a results table.

Note: If the track is used with the pillar start at the 5 cm mark and increase the height by 5 cm each time. Angle = height on scale divided by 2 when the end of the track is supported by the large bracket (so a rise of 5 cm will give an increase in slope of about 2.5°).

Analysing your results

- Enter your results in a table like the one below:-

Height of track (cm)	Angle of slope (°)	Speed from A to B (m/s^{-1})

- Draw a graph of angle vs. average speed.

Questions

1. How did the angle of the slope alter the speed?
2. Why did you need to start from the same position each time?

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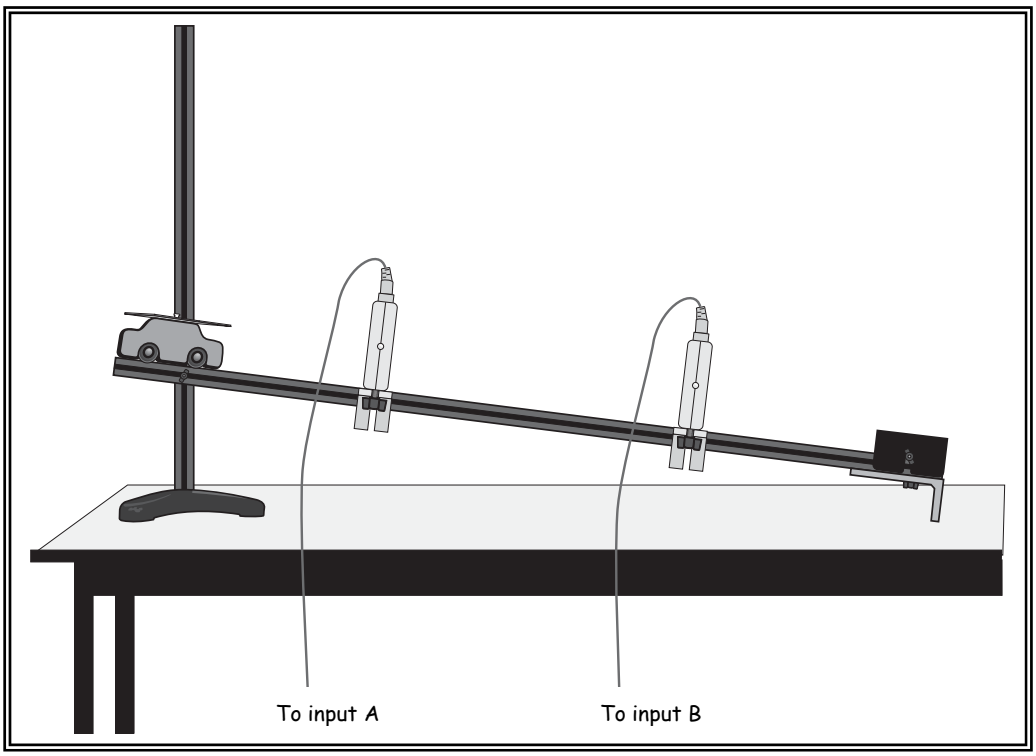
Ms05 - Measuring acceleration down a slope using two Light Gates

What you need

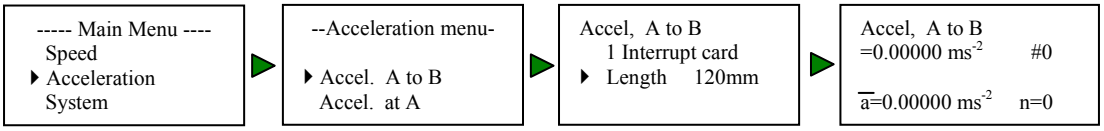
1. A Qt Digital Timer
2. 2 Smart Q Light Gates
3. Dynamics system track and pillar
4. 2 thin brackets to attach the Light Gates
5. Dynamics cart with single interrupt card
6. Crash box fitted to the end of the track



Note: The cart must go through the Light Gate connected to input A first.

What you need to do

1. Assemble the Dynamics system as shown in the diagram. Note the height of the track or the angle of slope.
2. Fit a crash box at the bottom of the track. Mark a start line on the track for the release of the cart.
3. Position the two Light Gates at about the 90 and 40 cm marks on the track. Connect the Light Gate at the near 90 cm mark to input A and the Gate at the near 40 cm mark to input B on Qt.
4. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gate.
5. Set up Qt to record **Acceleration A to B** with 1 interrupt card with a length of 120 mm:



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6. Place the cart in the start position at the top of the track and release the cart.
7. The acceleration will be displayed on the second line of Qt's display. Take the cart back to its start position and repeat two more times. The average acceleration is displayed on the bottom line of Qt's display. Note the average acceleration, current height and angle of slope in a results table.
8. Press the red ■ button to stop.
9. To give the data set a name, press ▲and scroll to Name data set. Select text or numbers to be used as the name, press ► to select as appropriate. Press ■to finish
10. Press ▼ to scroll to Repeat experiment and press ►to select.
11. Repeat with the track at five more heights/angles. Note the average acceleration for the three runs and the angle of the slope in a results table.

Note: If the track is used with the pillar start at the 5 cm mark and increase the height by 5 cm each time. Angle = height on scale divided by 2 when the end of the track is supported by the large bracket (so a rise of 5 cm will give an increase in slope of about 2.5°).

Analysing your results

- Enter your results in a table like the one below:-

Height of track (cm)	Angle of slope (°)	Acceleration A to B (m/s^{-2})

- Draw a graph of angle vs. average acceleration.

Questions

1. How did the angle of the slope alter the acceleration?
2. Why did you need to start from the same position each time?

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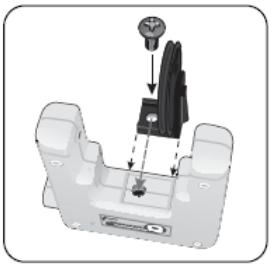
Teacher's notes for Ms06

Read

Qt Timer can use information from the stream of interrupts created by a spoked pulley rotating in a Light Gate to collect data as speed, time, distance and acceleration.

The spoked pulley screws onto the body of the Light Gate between the two arms that contain the transmitting LED and the receiving photodiode. As the pulley rotates each spoke breaks the light beam. Information about the diameter of the pulley and the spoke separation is used to calculate speed, acceleration and the distance travelled.



Attaching a Spoked Pulley to the Light Gate

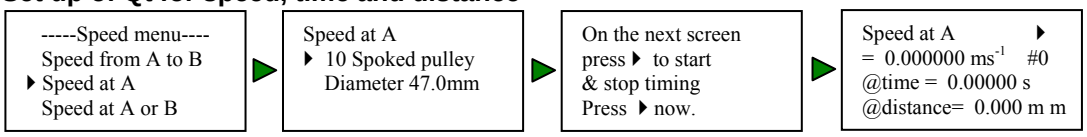
A string is attached to the cart and passed over the Pulley. A small counterweight on the string will hold the string against the Pulley. Any movement of the object will then cause the Pulley to rotate.

Notes

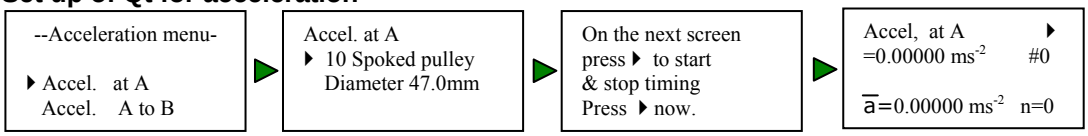
Check that the cart is running well by testing it along a horizontal track. If it is not running freely lubricate the bearings of the cart with WD40 (a light silicon based lubricant) or alcohol.

Place a small bracket across the track as a stop, positioned to stop the cart just before the weights hit the floor. This will prevent the weights falling off a hanger every time at the end of a run.

Set up of Qt for speed, time and distance

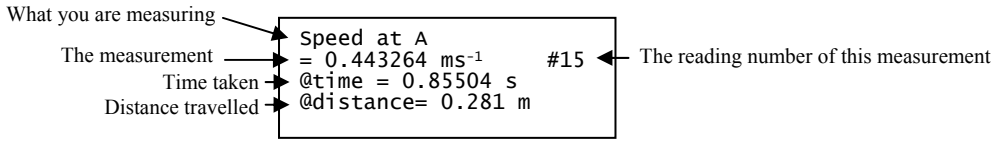


Set up of Qt for acceleration



Results and analysis

If the cart hits the stop before logging is stopped the last data points will be incorrect. When recording speed, time and distance this is not so much of a problem as the anomalous data at the end of the run can be ignored. If this happens when recording acceleration, the average acceleration value will not be correct so repeat the experiment.



The average measurement can be read from the bottom line of the display. You can scroll back through the values of speed/acceleration by using the ▲▼ buttons on Qt.
If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment.

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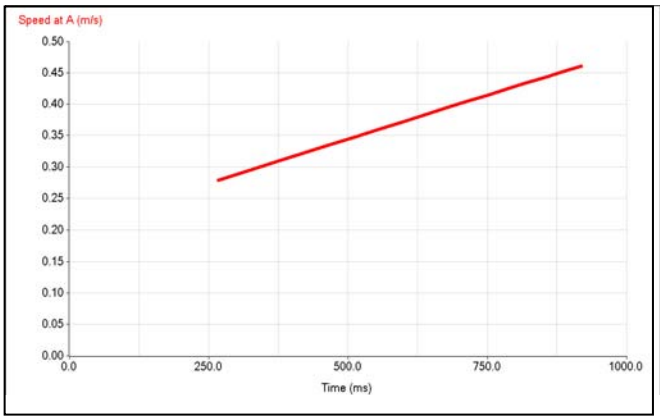
To review a data set on Qt press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

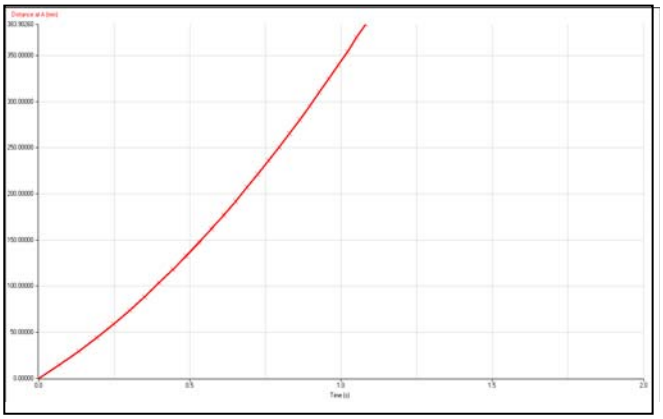
Retrieving data

If the data is retrieved to the EasySense software it can be converted between distance, speed and acceleration (open the EasySense program, select Remote, **Retrieve Remote** from the Home screen, and retrieve the data set). The data will be displayed as a time vs. speed graph.

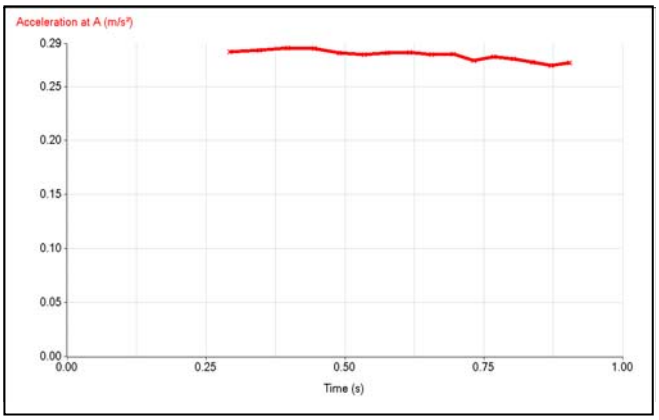
Original data as time vs. speed



To display a distance vs. time graph select **Show data** from the **Settings** menu and select distance.



For acceleration vs. time graph select **Show data** and select acceleration.



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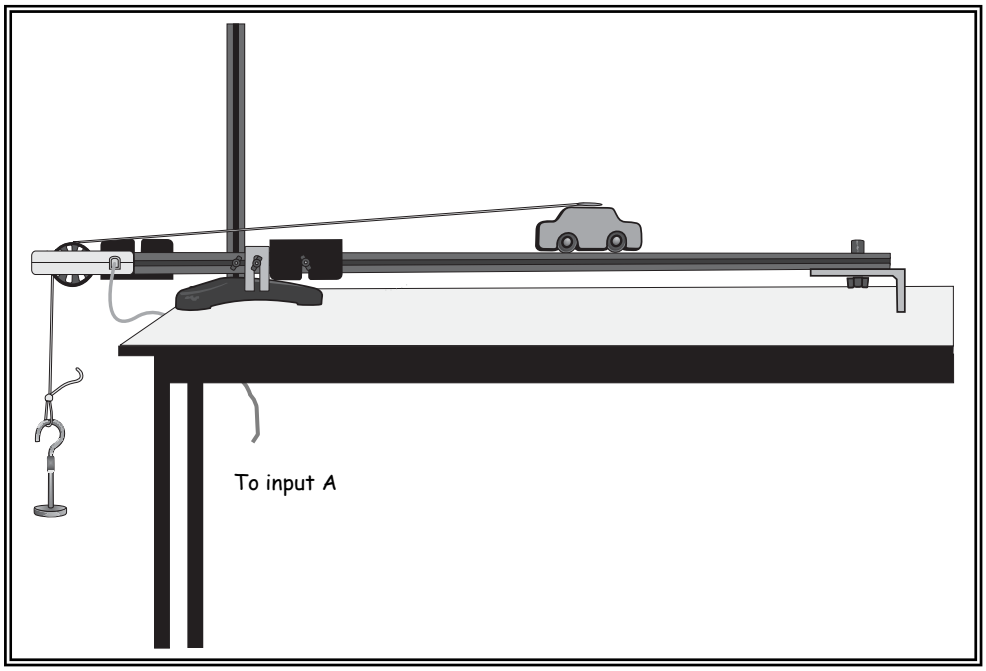
Ms06 – Measuring distance, speed and acceleration using one Light Gate and a spoked pulley

What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate with a Spoked pulley attached
3. Dynamics system track and pillar
4. 1 thin bracket (to act as a stop)
5. 3 large brackets (1 to attach the Light Gate, 2 to act as a crash barrier)
6. Dynamics cart
7. String with a 10 g mass hanger attached

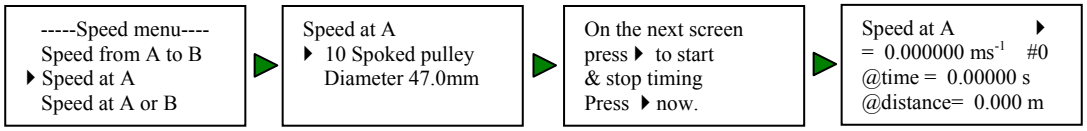


What you need to do

1. Assemble the Dynamics system as shown in the diagram. Adjust the track to be accurately horizontal. Place a thin bracket on the track close to the vertical pillar to act as a stop. Place two large brackets alongside the track to act as a crash barrier.
2. Connect a length of string with a 10 g mass hanger attached to the cart. Run the string over the top of the pulley (the mass is used to tension the string; it should not pull the cart or make the cart increase in speed).
3. Attach the spoked pulley to a Light Gate. Attach the Light Gate to the end of the track and connect to input A on Qt.

To measure speed, time and distance

4. Set up Qt to record **Speed at A** with the Spoked pulley:



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5. Release the cart from its start position and **immediately** press the ► button on Qt to begin logging.
6. Press the ► button again to pause logging before the cart hits the stop at the end of its run.

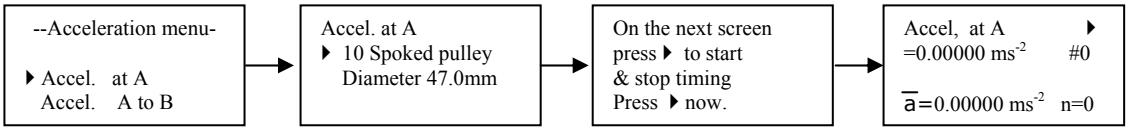
Analysing your results

- Scroll through the values using the ▲▼ buttons and transfer the data to a table, like the one below (ignore any abnormal results at the end of the run).
- Draw graphs of time vs. distance and time vs. speed.

Reading no.	Speed (ms^{-1})	at Time (s)	at Distance (m)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

To measure acceleration

1. Repeat the investigation as above but set up Qt to record **Acceleration at A** with a spoked pulley:



Note: To make sure the value for average acceleration is correct it is important to press the ► button to pause logging before the cart hits the stop at the end of its run.

2. Scroll through the values using the ▲▼ buttons and compare with the value for average acceleration.

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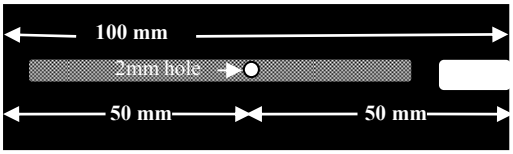
Teacher's notes for Ms07

Notes

If using the Dynamics systems pillar:

- Mount the Light Gate on a large bracket to give the adjustment needed to make the pendulum bob hang in the centre of the Light Gate when it is stationary. Use the moulding lines on the Light Gate to determine the centre position.
- Attach the short arm of the thin bracket to the pillar. Thread the end of a piece of string through the hole in the long arm of the bracket and secure in place e.g. by clamping with a crocodile clip.

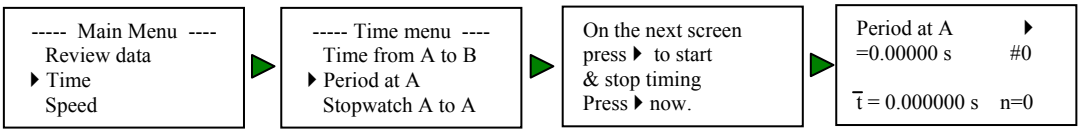
Note: Early versions of the thin brackets were not supplied with a hole – drill a 2 mm hole in the centre of the long arm of the bracket.



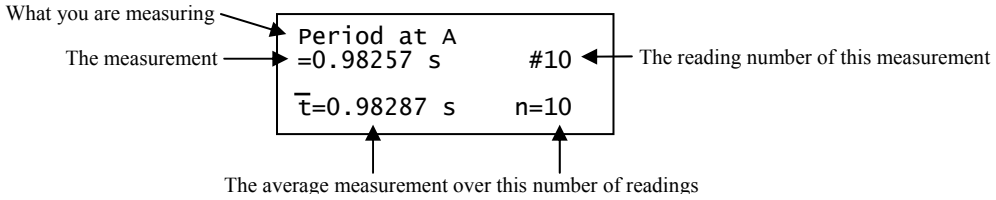
The pendulum bob should be cylindrical.

The pendulum length is from the point of suspension to the centre of gravity of the bob, not to the Light Gate. If a crocodile clip or a small bulldog clip is used to clamp the string, the length of the pendulum is easily altered. The pendulum swing should be small, less than 10 degrees from vertical.

Set up of Qt



Results and analysis


What you are measuring
The measurement
Period at A
=0.98257 s #10
t̄=0.98287 s n=10
The reading number of this measurement
The average measurement over this number of readings

The average measurement can be read from the bottom line of the display. You can scroll back through the values by using the ▲▼ buttons on Qt.

If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment.

To review data sets on Qt press the red ■ button to stop logging. Select Main Menu and press the green ▶ button. Use the ▲▼ buttons to scroll to **Review data** and press the green ▶ button. Select the data set you've just created and press the green ▶ button.

Sample results

Length (m)	Average Period T (s)	T^2 (s^2)
0.597	1.558	2.427364
0.527	1.467	2.152089
0.454	1.36	1.8496
0.368	1.224	1.498176
0.307	1.121	1.256641
0.235	0.983	0.966289

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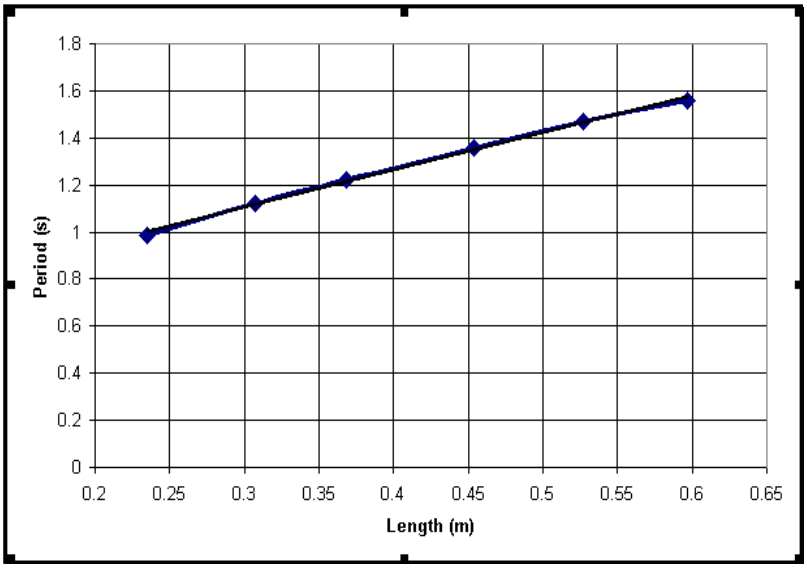
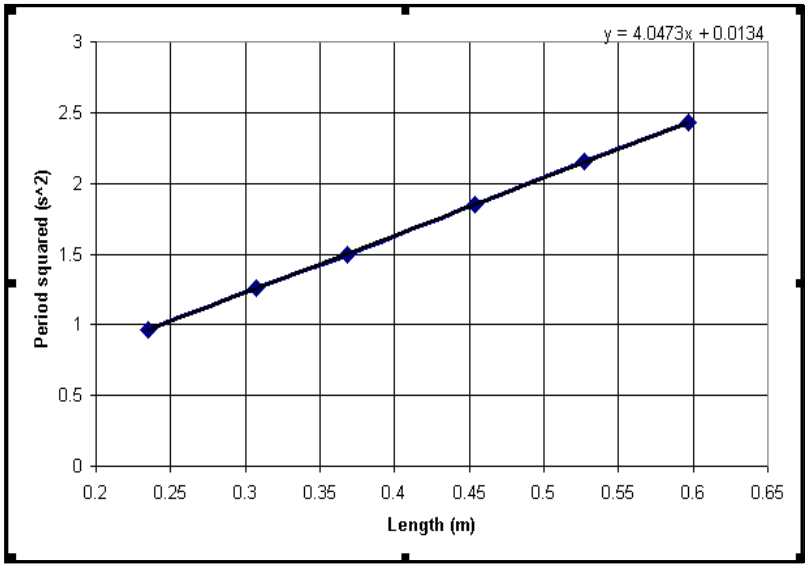
The data gave the following graphs (shown drawn in Excel).

Length vs. Period



Length vs. (Period)^2



Ms07 – Measuring change in the period of a simple pendululum using one Light Gate

Read

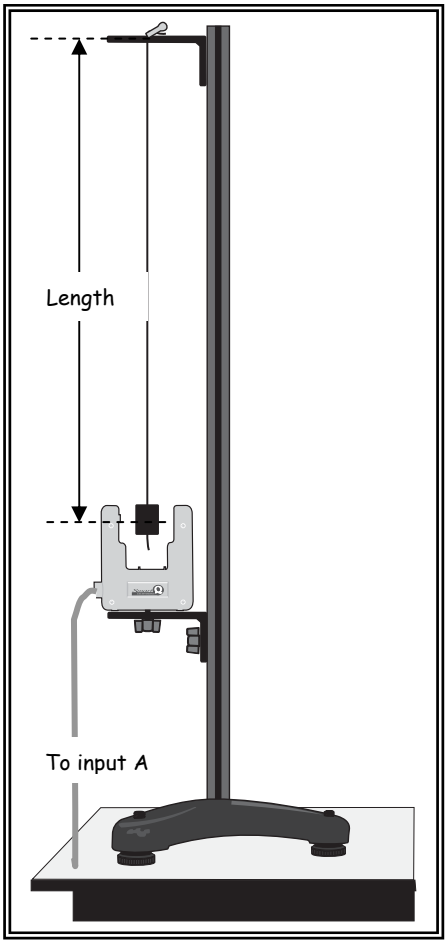
Galileo, a 17 year old medical student at the University of Pisa was attending a service in the cathedral. His mind was distracted by the great bronze lamp suspended from the high ceiling. The lamp had been drawn aside in order to light it and when released it oscillated to and fro with gradually decreasing amplitude. Using the beat of his pulse to keep time, he was surprised to find that the period of an oscillation of the lamp was independent of the size of the arc of oscillation. Later, by experiments he showed that the period of a swinging pendulum is also independent of the mass of the pendulum's bob and thus depends solely on the length of the pendulum.

Galileo did not have accurate clocks to use – so he improvised. Qt Timer has a very accurate clock. You will use it to investigate the relationship between the period of a pendulum and its length.

What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate
3. The Dynamics system pillar with:
   - 1 thin bracket – attach the short arm to the pillar (the string threads through the long arm of the bracket)
   - 1 large bracket to attach the Light Gate

   Or a retort stand with bossheads and clamp
4. A crocodile clip or small bull dog clip
5. Length of string or strong thread for the pendulum bob
6. A pendulum bob
7. A steel tape or metre rule



What you need to do

1. Assemble the apparatus as shown in the diagram. Connect the Light Gate to input A on Qt.
2. Attach the pendulum. Measure the length of the pendulum accurately from the point of suspension to the middle of the bob - start with a pendulum approximately 70 cm long. Write the length in a results table.

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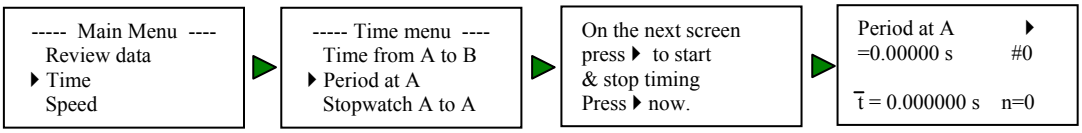
3. Make sure the bob lines up between the emitter and receiver on the Light Gate.
4. Set up Qt to record Period at A:



5. Pull the pendulum back no more than 10 degrees from vertical and release to set it swinging. Press the ► button on Qt to begin logging.
6. After at least 10 cycles press the ► button to pause logging.
7. Write the average time period for this length of pendulum in a results table like the one below.
8. Press the red ■ button to stop.
9. To give the data set a name, press ▲ and scroll to Name data set. Select text or numbers to be used as the name, press ► to select as appropriate. Press ■ to finish
10. Press ▼ to scroll to Repeat experiment and press ► to select. Reduce the length of the string by about 6 cm and repeat.
11. Continue repeating the experiment (reducing the length by 6 cm each time) until the length is about 20 cm (you need at least 6 sets of results).

Analysing your results

- Enter your results in a table like the one below:-

Length - L (cm)	Average period -T (s)	T^2 (s^2)

- Draw graphs of T (period) vs. L (length), and T^2 versus L.

Questions

1. How does the period of a pendulum vary with an increase in the length of the pendulum?
2. What is the relationship between the length (L) of the pendulum and the square of the period (T^2)?
3. From your results, can you find the length of a pendulum with a period of 1 second?

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Gravity

Teacher's notes for Gs01 to Gs04

The normal value taken for the accelerating force due to gravitational pull is 9.82 ms^{-2}. For ease of calculation this is often rounded up to a value of 10 ms^{-2}.

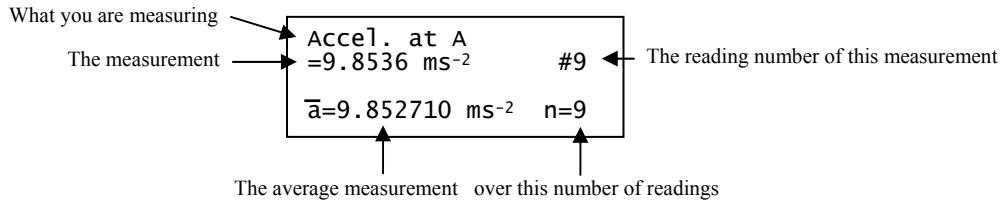
Due to the constant value of g in a particular location, measurements of g are often taken to measure the measurers' accuracy and technique. Qt used with the cards from the Data Harvest Interrupt Card set should give values very close to expected.

This is a classic example of the intervention of the observer, if the first trial gives 9.81 ms^{-2} there is unlikely to be an attempt to repeat. If the first value recorded is 10.3 ms^{-2} then the observer will undertake repeats until the expected result is achieved. The experiment is then stopped and the expected result taken as the experimental result.

Acceleration due to gravity can be measured with the Qt using:

- A double interrupt card and single Light Gate (Gs01), measuring the velocity of each segment as it passes through the Light Gate and calculating acceleration.
- A single interrupt card and single Light Gates measuring speed at over a known distance (Gs02) and using the values to calculate acceleration,
- A single interrupt card and two Light Gates (Gs03) to calculate acceleration,
- A multiple segment interrupt card (picket fence) (Gs04) and a single Light Gate, measuring the velocity of each segment as it passes through the Light Gate and calculating acceleration. The result is many measurements of g.

Results and analysis



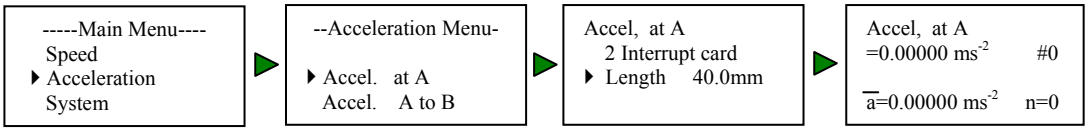
The average measurement can be read from the bottom line of the display. You can scroll back through the values of speed/acceleration by using the ▲▼ buttons on Qt.

If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment.

To review data sets on Qt press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

Gs01 - Measuring 'g' with a single Light Gate

Set up of Qt



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Notes

Drop the card as vertically as possible. Encourage students to hold the card at the centre top edge before dropping it.
Try to start with the bottom edge of the card just above the Light Gate; this reduces the turning of the card before it enters the Light Gate. Drop the card close to the receiver side of the Light Gate; this is the side without the socket.

Errors

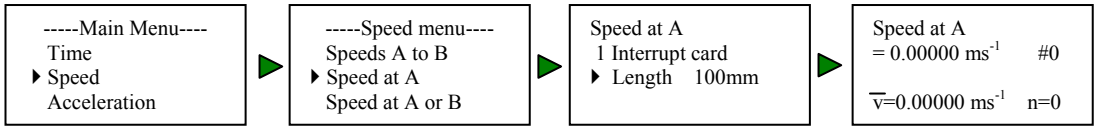
The length of the double interrupt card is used twice when calculating **Acceleration at A** so any measurement error will be doubled.

The infrared beam has a finite width. It is in excess of 1 mm and varies with the distance from the emitter and receiver. The trigger voltage will be different on the rising and falling edges. The effect of these factors is to cause uncertainties in the effective length of the interrupts.

When using interrupts of 40 mm an uncertainty of 0.5 mm at each end of the interrupt will result in errors of the order of 5% in the value of g.

Gs02 - Measuring 'g' by logging velocity over a known distance (d)

Set up of Qt



Notes

Drop the card as vertically as possible. It may help if the centre of the top edge of the card is marked to encourage students to hold the card on that mark before dropping it.

It helps to weight the lower edge of the card with two evenly spaced 10 g masses on each side of the card.

Use a thin bracket to mark the position from which to drop the card.

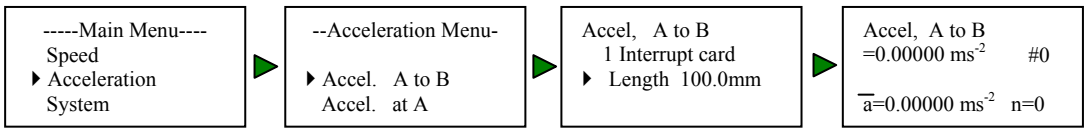
Sample results

Distance travelled (s) = 0.25 m
Average value for v = 3.15141

$$g = \frac{v^2}{2s} = \frac{3.15141^2}{0.5} = 9.93\ ms^{-2}$$

Gs03 - Using two Light Gates to measure g

Set up of Qt



Notes

Drop the card as vertically as possible. It may help if the centre of the top edge of the card is marked to encourage students to hold the card on that mark before dropping it.

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It helps to weight the lower edge of the card with two evenly spaced 10 g masses on each side of the card.

Try to start with the bottom edge of the card just above the Light Gate; this reduces the turning of the card before it enters the Light Gate. Drop the card close to the receiver side of the Light Gate; this is the side without the socket

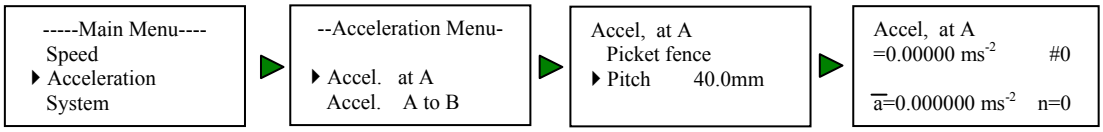
Errors

The main source of error is not dropping the card vertically.
The infrared beam has a finite width. It is in excess of 1 mm and varies with the distance from the emitter and receiver. The trigger voltage will be different on the rising and falling edges. The effect of these is to cause uncertainties in the effective length of the interrupts.

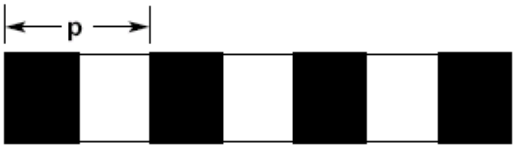
When using interrupts of 100 mm, an uncertainty of 0.5 mm at each end of the interrupt will result in errors of the order of 2% in the value of g.

Gs04 - Measuring g using a multi-segmented interrupt card (picket fence)

Set up of Qt



Note: The multi-segmented card (picket fence) supplied in the Data Harvest Interrupt Card set has a pitch of 40 mm. If this is not being used, insert the pitch length of the card used.



Notes

Care should be taken to drop the multi-segmented interrupt card (picket fence) as vertically as possible.

Try to start with the bottom edge of the card just above the Light Gate; this reduces the turning of the card before it enters the Light Gate. Drop the card close to the receiver side of the Light Gate; this is the side without the socket

Place a soft cloth in the catching box to cushion the fall of the card and reduce its rebound.

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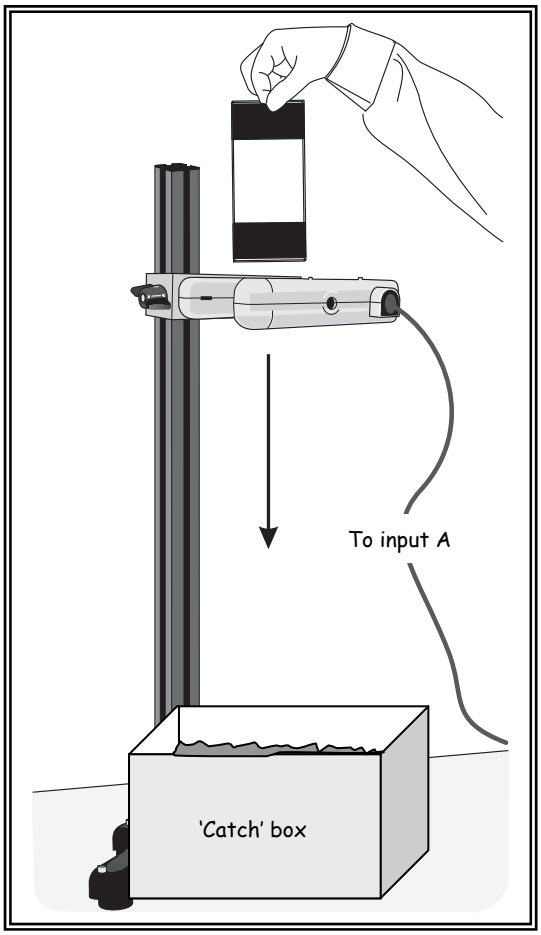
Gs01 – Measuring acceleration due to gravity using one Light Gate and a double interrupt card

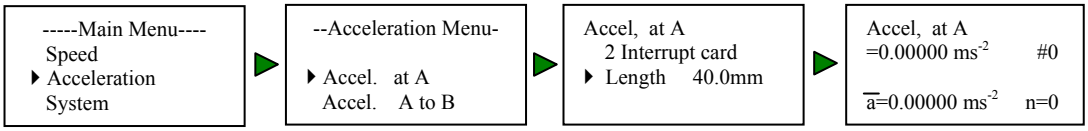
What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate
3. Either the Dynamics system pillar with a thin bracket to attach the Light Gate or a bosshead and retort stand
4. A double interrupt card



What you need to do

1. Assemble the Dynamics pillar and Light Gate as shown in the diagram. Connect the Light Gate to input A on Qt.
2. The double interrupt card needs to drop vertically. Protect the bench with a 'catching box' containing soft material (practice a few times before collecting data).
3. Set up Qt to record **Acceleration at A** using a 2 interrupt card with a segment length of 40 mm:



4. Drop the interrupt card through the Light Gate about 5 times. Make sure you drop it cleanly through the Gate.
5. You can scroll back through the values of speed by using the ▲▼ buttons. If there are no obviously erroneous results, note the average value for acceleration.

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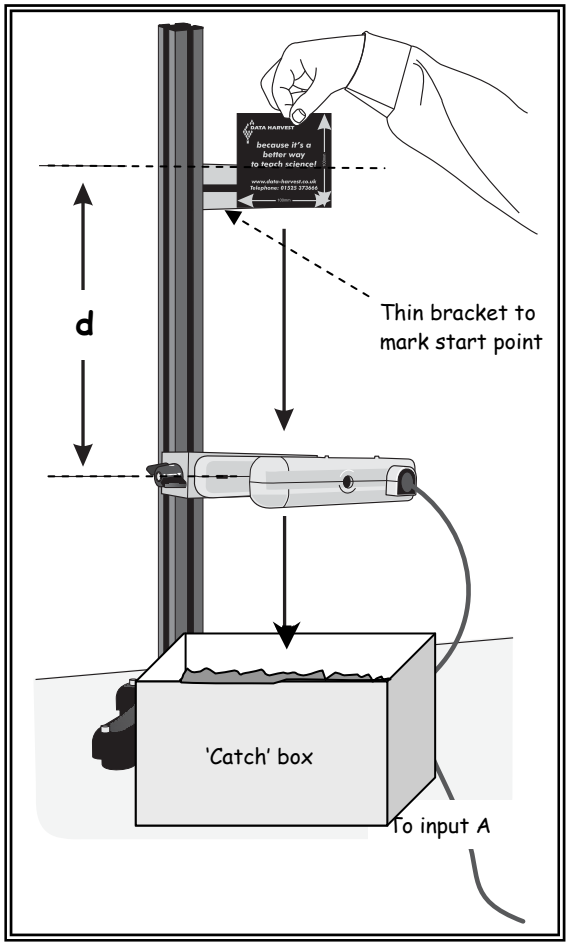
Gs02 - Measuring acceleration due to gravity using one Light Gate to log velocity over a known distance (d)

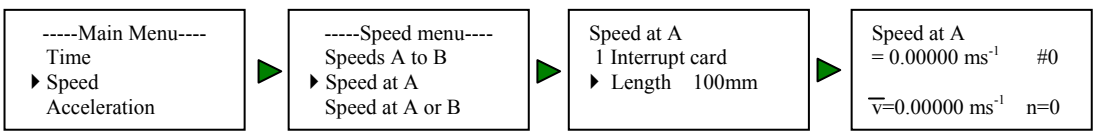
What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate
3. Either the Dynamics system pillar with 2 thin brackets, one to mark a start point and the other to attach the Light Gate or a bossheads and retort stand
4. Ruler to measure d
5. A single, weighted, interrupt card



What you need to do

1. Assemble the apparatus as shown in the diagram. Connect the Light Gate to input A on Qt. Mark a start point for the drop to ensure the interrupt card is always dropped from the same height.
2. Measure distance (d) - this is the distance from the centre of the interrupt card and to the centre line of the Light Gate.
3. Protect the bench with a 'catching box' containing soft material (practice a few times before collecting data).
4. Set up Qt to record **Speed at A** with a 1 interrupt card that has a length of 100 mm:



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5. Drop the interrupt card through the Light Gate from the start position.
6. Repeat several times, dropping the card from the same point each time.
7. You can scroll back through the values of speed by using the ▲▼ buttons. If there are no obviously erroneous results, note down the average value for speed (v).

Theory

For an object falling under gravity, the equation is: $v^2 = u^2 + 2gs$

v = final velocity
u = initial velocity
g = acceleration due to gravity
s = distanced (d) travelled

If the initial velocity (u) is zero the equation becomes: $v^2 = 2gs$

Therefore: $\boldsymbol{g} = \frac{\mathbf{v^2}}{\mathbf{2s}}$

Analysing your results

Calculate 'g' from the equation: $\boldsymbol{g} = \frac{\mathbf{v^2}}{\mathbf{2s}}$

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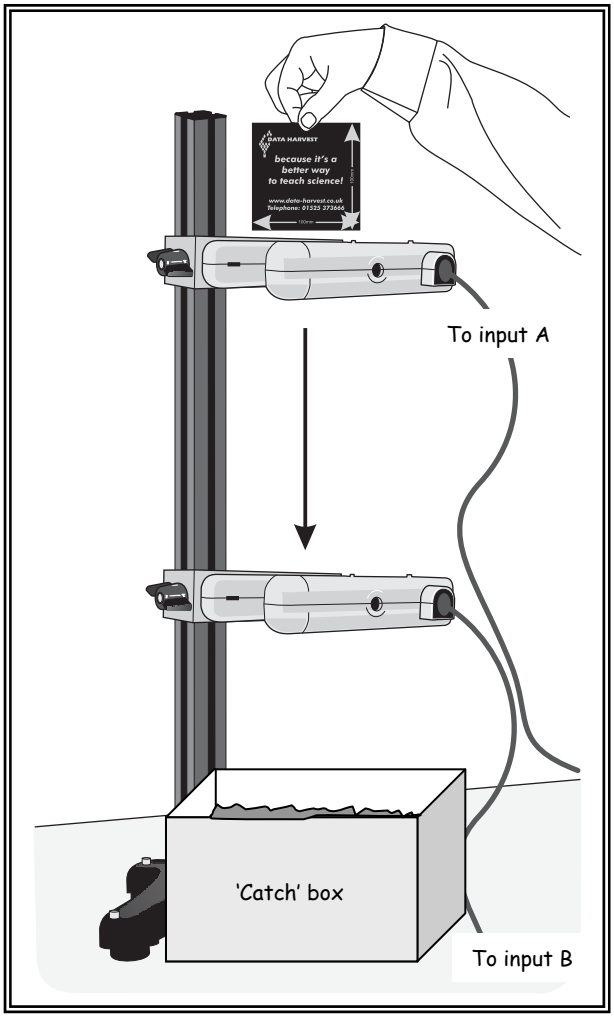
Gs03 - Measuring acceleration due to gravity using two Light Gates and a single interrupt card

What you need

1. A Qt Digital Timer
2. 2 Smart Q Light Gates

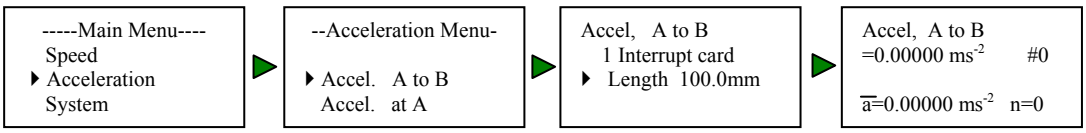
   Note: Light Gate A should be the first Light Gate the interrupt card falls through

3. Either the Dynamics system pillar with 2 thin brackets to attach the Light Gates or bossheads and retort stand
4. A single, weighted, interrupt card



What you need to do

1. Assemble the apparatus as shown in the diagram. Connect the Light Gate at the top to input A on Qt. Connect the Light Gate below to input B. Protect the bench with a 'catching box' containing soft material (practice a few times before collecting data).
2. Set up Qt to record **Acceleration from A to B** with a 1 interrupt card that has a length of 100 mm:



3. Drop the interrupt card through the Light Gates. Repeat at least four times.
4. You can scroll back through the values of speed by using the ▲▼ buttons. If there are no obviously erroneous results, note the average value for acceleration.

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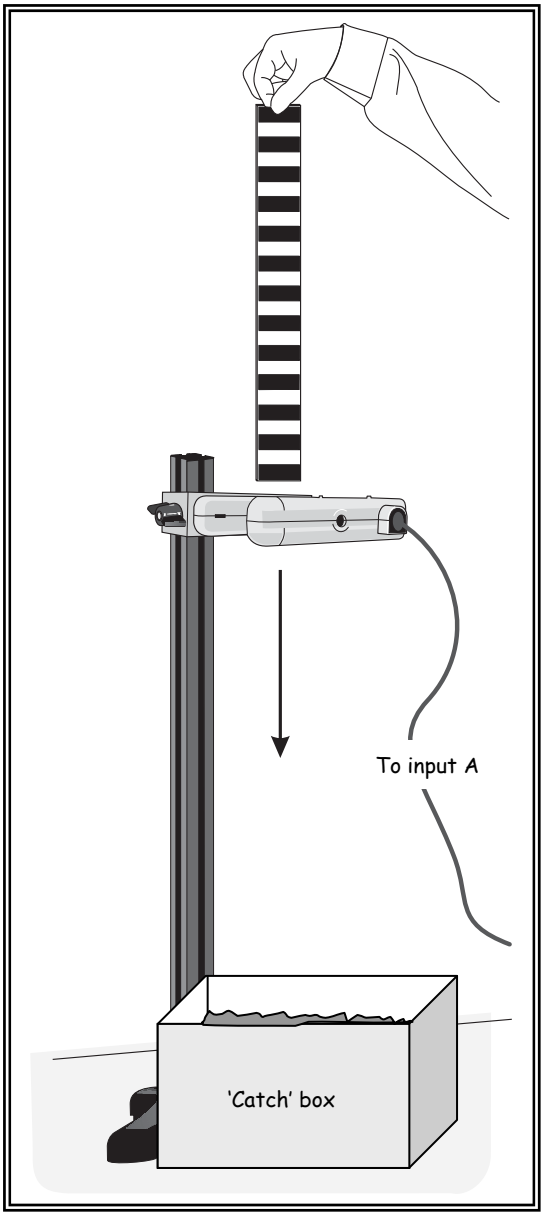
Gs04 - Measuring acceleration due to gravity using one Light Gate and a multi-segmented interrupt card

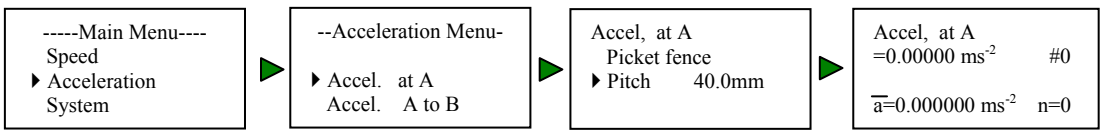
What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate
3. Either a Dynamics system pillar with a thin bracket to attach the Light Gate or a bosshead and retort stand
4. A multi-segmented interrupt card (picket fence)



What you need to do

1. Assemble the apparatus as shown in the diagram. Connect the Light Gate to input A on Qt. Make sure you are able to hold the multi-segmented card above the apparatus and that there is enough space below the Light Gate for the fence to fall completely through.
2. The picket fence can bounce on landing; place a soft cloth in the catch box to dampen the fall.
3. Set up Qt to record **Acceleration at A** with a Picket fence that has a pitch of 40 mm:



4. Hold the picket fence just above the Light Gate, and drop it vertically.
5. You can scroll back through the values of acceleration by using the ▲▼ buttons. If there are no obviously erroneous results, note the average value for acceleration.
6. Press the red ■ button to stop. Press ▼ to scroll to Repeat experiment and press ▶ to select. Repeat twice more and take the average of the 3 values of g you obtain.

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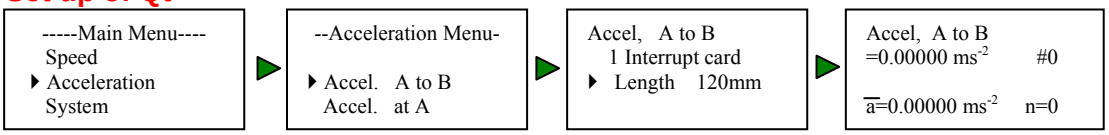
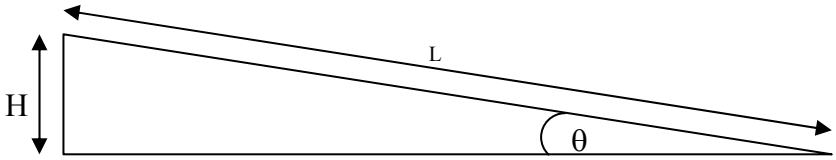
Teacher's notes for Gs05

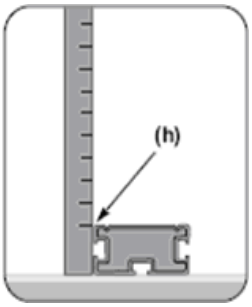
Set up of Qt



Notes

Do not start with the track set at a large angle. About 2.5° is enough. If used with the pillar, fix the track to the 5 cm mark (Angle = height on scale divided by 2 when the end of the track is supported by the large bracket).





Sin θ = the height (h) ÷ length of the track (L).

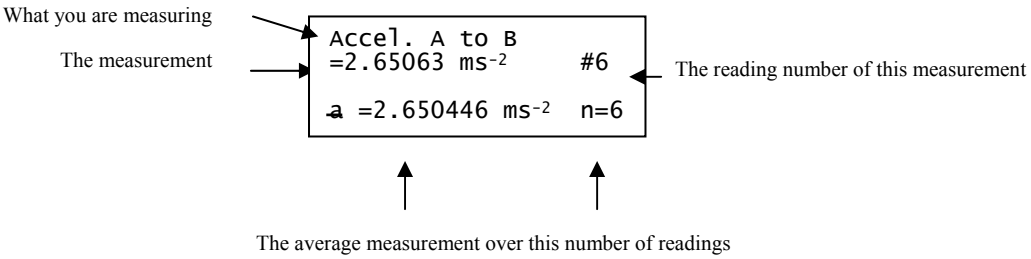
L = Length of the track between its pivot point - from the point at which the track is attached to the pillar to the end of the track (when the large bracket is fitted flush this is also the end of the track)
H = height from the position of the track when horizontal

Fit a crash box to the end of the track. As the angle of the slope increases so will the speed of the cart.

Make sure the interrupt card is correctly positioned. There are locating pegs on the card and locating holes on the body of the cart to make this easier. The attachment screw should only be finger tight.

Check that the cart is running well by testing it along a horizontal track. If it is not running freely lubricate the bearings of the cart with WD40 (a light silicon based lubricant) or alcohol.

Results and analysis


What you are measuring
The measurement
Accel. A to B
=2.65063 ms-2 #6
a =2.650446 ms-2 n=6
The reading number of this measurement
The average measurement over this number of readings

The average measurement can be read from the bottom line of the display. You can scroll back through the values of acceleration by using the ▲▼ buttons on Qt.

If you intend to review a data set, when you press■it maybe useful to Name the data set before selecting Repeat experiment.

To review a data set on Qt, press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

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Sample results

Height h (cm)	Length L (cm)	Sin θ = h/L	Average acceleration (ms^{-2})
5	108	0.04630	0.3868
10	108	0.09259	0.8355
15	108	0.13889	1.2809
20	108	0.18519	1.7360
25	108	0.23148	2.1945
30	108	0.27778	2.6504

$P = mg \sin \theta - F$

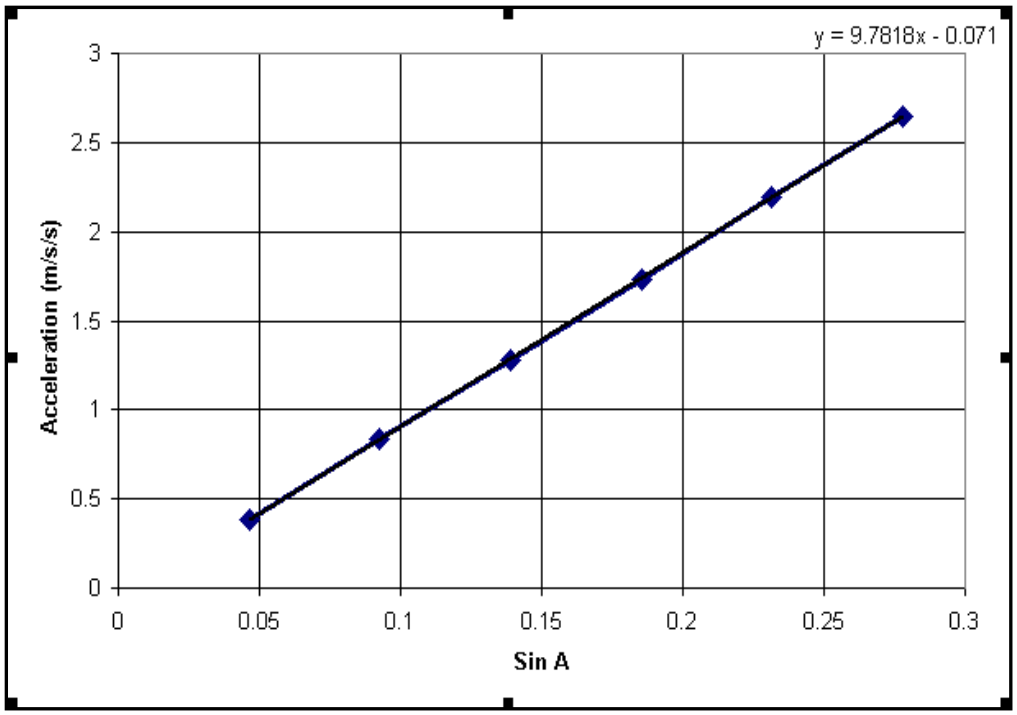
$a = \frac{mg \sin \theta - F}{m}$

$a = mg \sin \theta - \frac{F}{m}$

m = mass of the cart and attachments
g = acceleration due to gravity
F = friction force acting up the slope
P = accelerating force down the slope

Assuming that **F** and **m** are constant then a plot of **acceleration** against **sin θ** will give a straight line. The gradient of the line will give **g**.

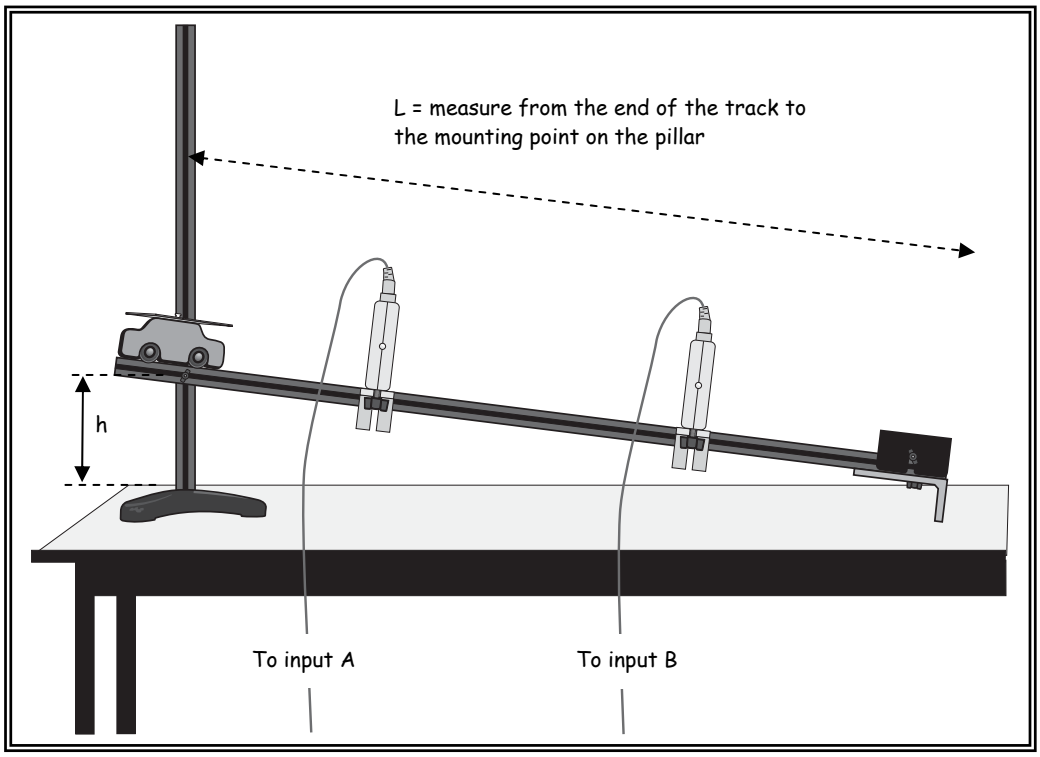
The data gave the following graph (shown drawn in Excel): - **g = 9.782 ms^{-2}**



Gs05 - Measuring acceleration due to gravity down a slope using two Light Gates (diluted gravity)

What you need

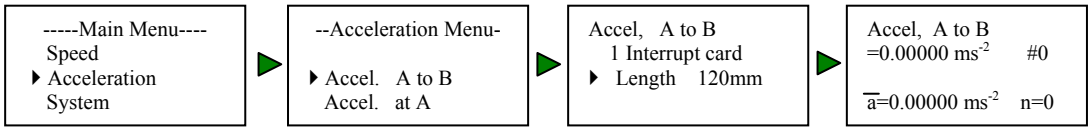
1. A Qt Digital Timer
2. 2 Smart Q Light Gates
3. Dynamics system track and pillar
4. 2 thin brackets to attach the Light Gates
5. Dynamics cart with single interrupt card
6. Crash box fitted to the end of the track



Note: The cart must go through the Light Gate connected to input A first.

What you need to do

1. Assemble the Dynamics system as shown in the diagram. Attach the track to the pillar at the 5 cm mark (angle A). Make sure the large bracket is flush with the end of the track. Note the height and length of the track in a results table. Fit a crash box at the bottom of the track.
2. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gate.
3. Position the two Light Gates approximately at the 90 and 40 cm marks on the track. Connect the Light Gate at the 90 cm mark to input A and the Gate at the 40 cm mark to input B on Qt.
4. Set up Qt to record **Acceleration from A to B** with 1 Interrupt card with a length of 120 mm:



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5. Place the cart in the start position at the top of the track and release.
6. The acceleration from A to B will be displayed on Qt's display. Take the cart back to its start position and repeat two more times.
7. Write the average acceleration in a table like the one below.
8. Press the red ■ button to stop. Press ▼ to scroll to Repeat experiment and press ► to select.
9. Repeat for five more heights/angles, increasing the height by about 5 cm each time.

Analysing your results

Length of the track L = …… cm

- Calculate the values of sin θ for each height (sin θ = the height ÷ length of the track).

Height h (cm)	Length L (cm)	Sin θ = h/L	Average acceleration (ms^{-2})
5			
10			
15			
20			
25			
30			

$P = mg \sin\theta - F$

$a = \frac{mg \sin\theta - F}{m}$

$a = mg \sin\theta - \frac{F}{m}$

m = mass of the cart and attachments
g = acceleration due to gravity
F = friction force acting up the slope
P = accelerating force down the slope

Assuming that **F** and **m** are constant then a plot of **a** against **sin** θ will give a straight line. The gradient of the line will give **g**.

- Draw a graph of sin θ vs. average acceleration.
- Draw a line of best fit. Measure the gradient of the best fit line to find **g**.

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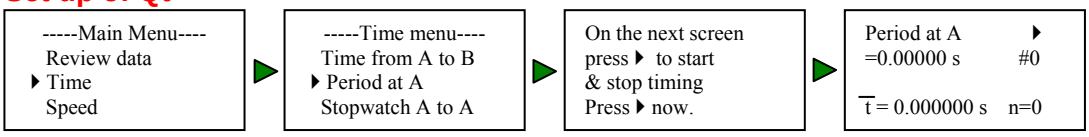
Teachers notes for Gs06

Set up of Qt

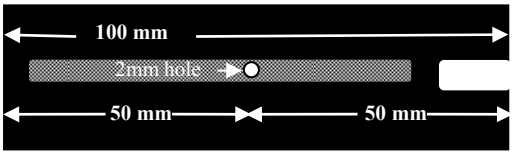


Notes

If using the Dynamic systems pillar:

- Mount the Light Gate on a large bracket so that the pendulum bob hangs in the centre of the Light Gate when it is stationary. Use the moulding lines on the Light Gate to determine the centre position.
- Attach the short arm of the thin bracket to the pillar. Thread the end of a piece of string through the hole in the long arm of the bracket and secure in place e.g. clamp with a crocodile clip.

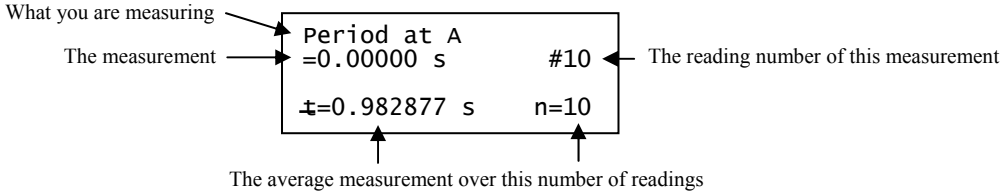
Note: Early versions of the thin brackets were not supplied with a hole – drill a 2 mm hole in the centre of the long arm of the bracket.



The pendulum bob should be cylindrical.

The pendulum length is from the point of suspension to the centre of gravity of the bob, not to the Light Gate. If a crocodile clip or a small bulldog clip is used to clamp the string, the length of the pendulum is easily altered. The pendulum swing should be small, less than 10 degrees from vertical.

Results and analysis


What you are measuring
The measurement
Period at A
=0.00000 s #10
The reading number of this measurement
t=0.982877 s n=10
The average measurement over this number of readings

The average measurement can be read from the bottom line of the display. You can scroll back through the values by using the ▲▼ buttons on Qt.

If you intend to review a set of data or retrieve to the EasySense **s**oftware it is useful to **Name the data set** before selecting Repeat experiment.

To review data sets on Qt press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

Sample results and analysis

Length (m)	Period T (s)	T^2 (s^2)
0.597	1.558	2.427364
0.527	1.467	2.152089
0.454	1.36	1.8496
0.368	1.224	1.498176
0.307	1.121	1.256641
0.235	0.983	0.966289

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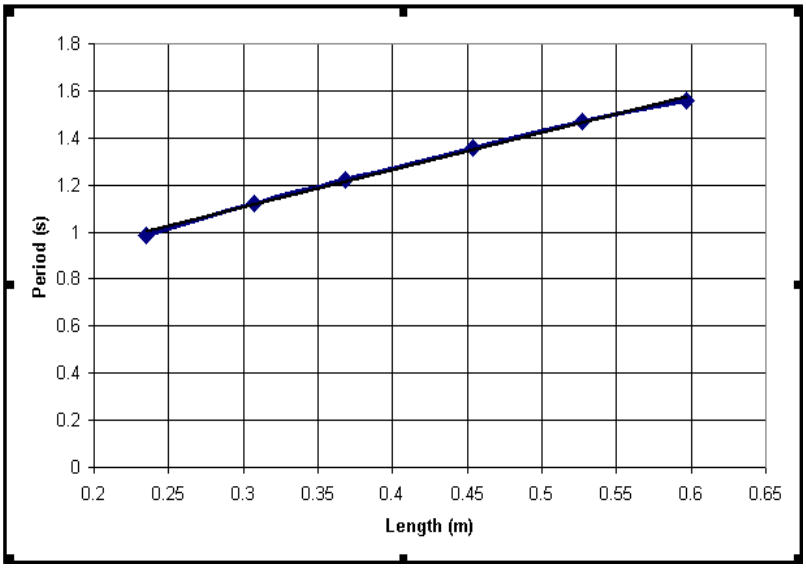
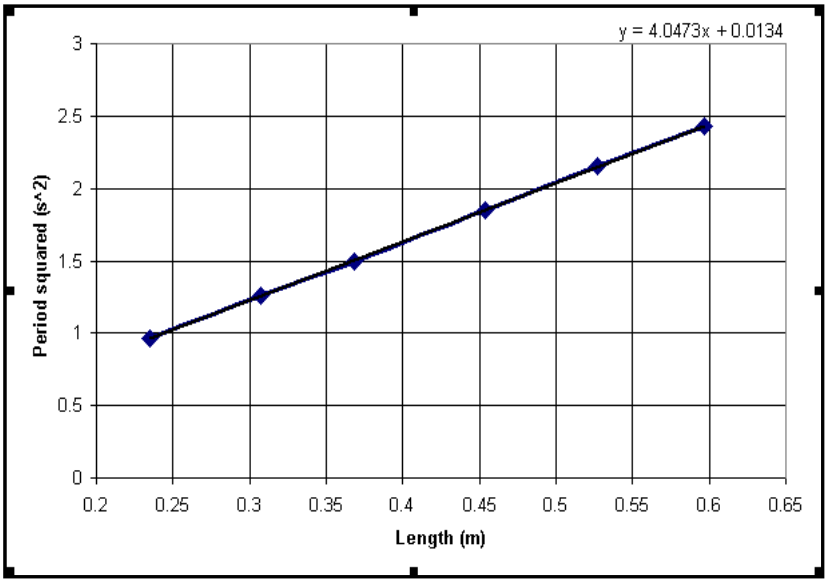
The data gave the following graphs (shown drawn in Excel)

Length vs. Period



Length vs. (Period)^2



Gradient = $\frac{4\pi^2}{g}$ therefore $g = \frac{4\pi^2}{\text{Gradient}}$

$g = \frac{4\pi^2}{4.0473} = 9.754\ ms^{-2}$

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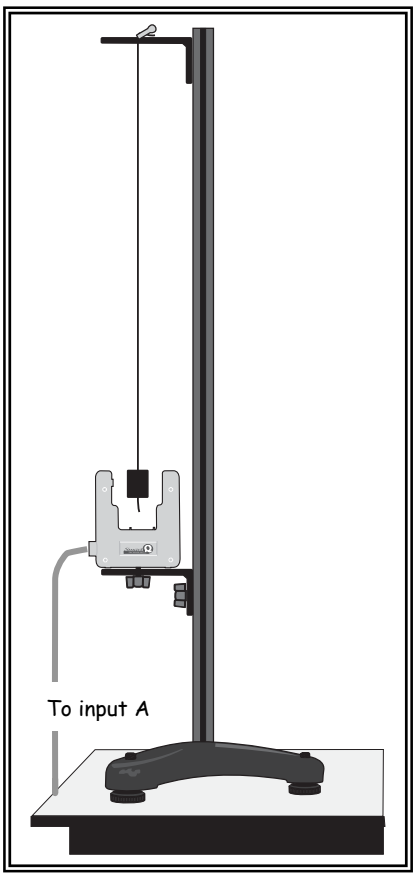
Gs06 - Measuring acceleration due to gravity with a simple pendulum and one Light Gate

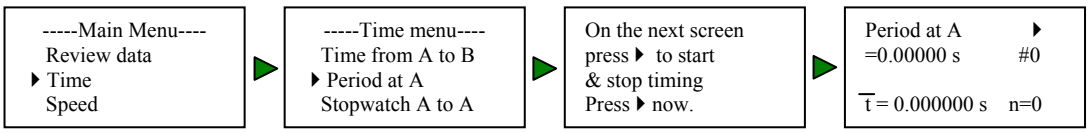
What you need

1. A Qt Digital Timer
2. A Smart Q Light Gate
3. Either the Dynamics system pillar with a thin bracket – attach the short arm to the pillar (the string threads through the long arm of the bracket) or a retort stand with bossheads and clamp
4. 1 large bracket to attach the Light Gate
5. A crocodile clip or small bull dog clip
6. Length of string or strong thread for the pendulum bob
7. A pendulum bob
8. A steel tape or metre rule



What you need to do

1. Assemble the apparatus as shown in the diagram. Connect the Light Gate to input A on Qt.
2. Attach the pendulum. Measure the length of the pendulum accurately from the point of suspension to the middle of the bob - start with a pendulum approximately 70 cm long. Write the length in a results table.
3. Make sure the bob hangs accurately between the emitter and receiver on the Light Gate.
4. Set up Qt to record Period at A as follows:-



5. Pull the pendulum back to about 10 degrees from vertical and release. Press the ▶ button on Qt to begin logging.
6. After at least 10 cycles press the ▶ button to pause logging.
7. Write the average time period for this length of pendulum in a results table.
8. Press the red ■ button to stop. Press ▼ to scroll to Repeat experiment and press ▶ to select. Reduce the length of the string by about 6 cm and repeat.
9. Continue repeating the experiment (reducing the length by 6 cm each time) until the length is about 20 cm (you need at least 6 sets of results).

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Analysing your results

Length - L (cm)	Average Period - T (s)	Period squared -T^2 (s^2)

1. Draw a graph of length (L) vs. T^2.
2. Calculate the gradient of the L vs. T^2 graph, and hence calculate g

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Squaring the above equation gives:- $T^2 = 4\pi^2 \frac{L}{g}$

Gradient = $\frac{4\pi^2}{g}$ therefore $\boldsymbol{g} = \frac{4\pi^2}{\text{Gradient}}$

Questions

1. What are the sources of error in the final result?
2. Discuss whether these errors are likely to increase or decrease the final value for g.

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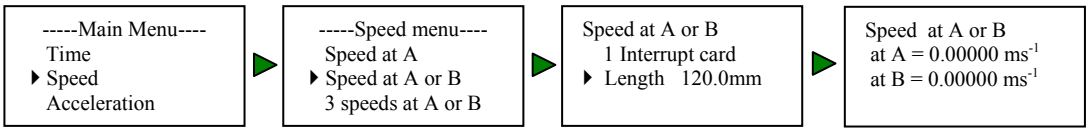
Forces

Teacher's notes for Fs01 to Fs02

Fs01 - Measuring balanced forces

In this investigation motion with a balanced force is measured by Light Gates at fixed points on the Dynamics system track.

Setup of Qt



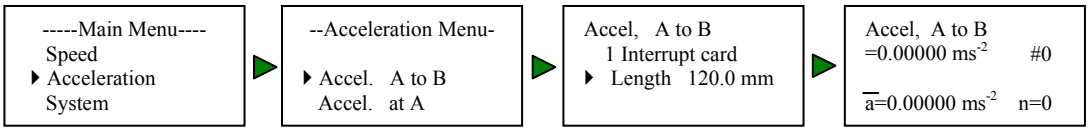
Notes

Check that the cart is running well by testing it along a horizontal track. If it is not running freely lubricate the bearings of the cart with WD40 (a light silicon based lubricant) or alcohol.

Fs02 - Investigating Newton's 2nd Law using 2 Light Gates

In this investigation a force will be measured by the motion / change in motion it creates. The student will use a cart (with very low friction) to investigate how the velocity of an object changes when it has steady resultant force acting on it to discover the relationship between force, mass and acceleration (as described by Newton's 2nd law).

Set up of Qt



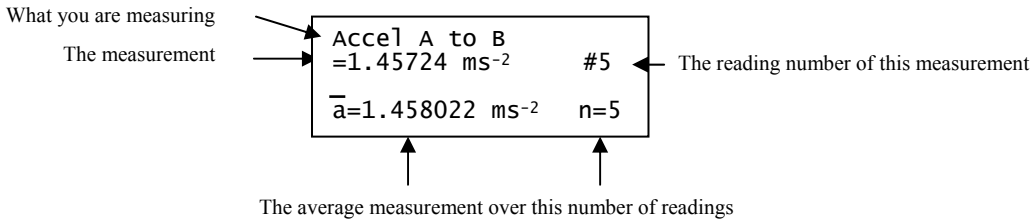
Notes

Check that the cart is running well by testing it along a horizontal track. If it is not running freely lubricate the bearings of the cart with WD40 (a light silicon based lubricant) or alcohol.

Place a thin bracket on the track to act as an end stop close to the vertical pillar. Use two large brackets as crash barriers in front of the end stop to help prevent the cart from jumping off the track.

This investigation can be also be done using a single Light Gate with a double interrupt card but the results will not be as accurate as there will be no compensation for friction.

Results and analysis


What you are measuring
The measurement
Accel A to B
=1.45724 ms-2 #5
a=1.458022 ms-2 n=5
The reading number of this measurement
The average measurement over this number of readings

The average measurement can be read from the bottom line of the display. You can scroll back through the values by using the ▲▼ buttons on Qt.

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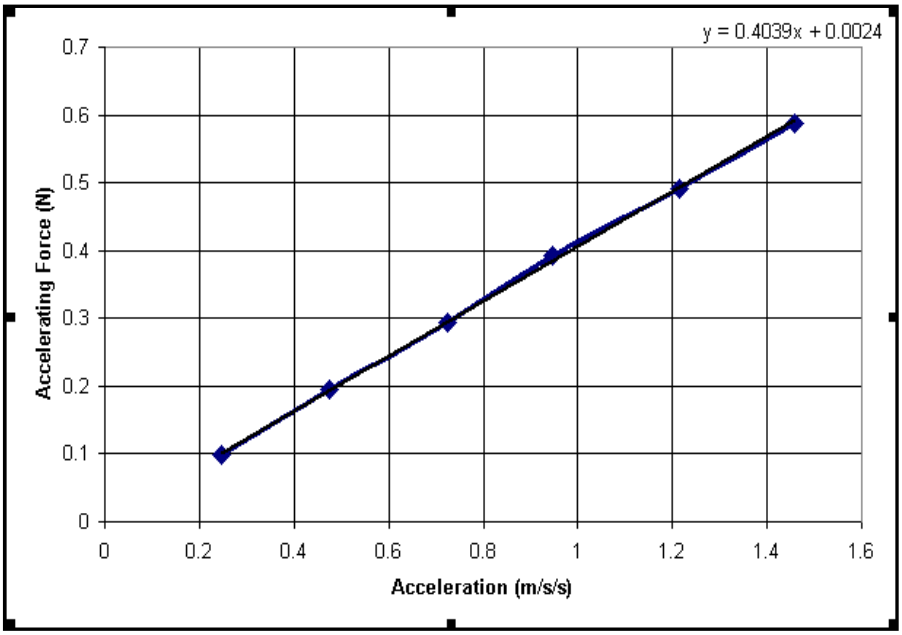
If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment.

To review a data set on Qt press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

Sample results
Total moving mass = 0.397 kg

Falling mass (kg)	Accelerating force (N)	Acceleration (m/s/s)
0.01	0.0981	0.246671
0.02	0.1962	0.474088
0.03	0.2943	0.725504
0.04	0.3924	0.947890
0.05	0.4905	1.213112
0.06	0.5886	1.458022

The data gave the following graph (shown drawn in Excel):



Gradient = 0.404 kg (within 2% of the actual moving mass).

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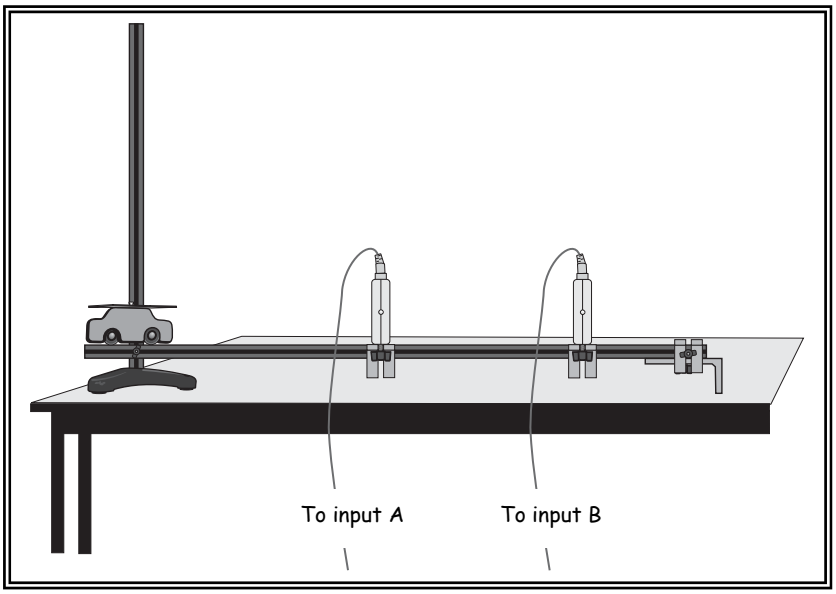
Fs01 – Measuring balanced forces using two Light Gates

Read

The condition for staying still or moving with a uniform velocity is that there is no resultant force acting on a body. Common experience tells us that objects at rest do not move unless a force is applied to them. The force that produces motion is the vector sum of all the forces acting on the object. If the resultant of these forces is zero then the object remains still or carries on moving at a constant velocity. If the resultant force is greater than zero then the velocity will change in the direction of the resultant force.

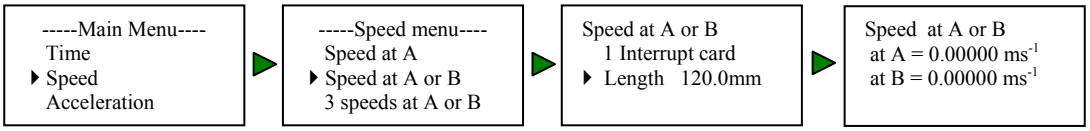
What you need

1. A Qt Digital Timer
2. 2 Smart Q Light Gates
3. Dynamics system track and pillar
4. 2 thin brackets to attach the Light Gates
5. Dynamics cart with single interrupt card
6. Thin bracket to act as stop.



What you need to do

1. Assemble the Dynamics system as shown in the diagram with the two Light Gates approximately 50 cm apart. Connect the Light Gates to input A and B on Qt.
2. Adjust the track to be horizontal.
3. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gates.
4. Set up Qt to record **Speed at A or B** with 1 interrupt card with a length of 120 mm:



5. Push the cart gently from the pillar end to run freely along the track through the two Light Gates, in the direction A to B.
6. When the values for speed are the same at both A and B, the forces acting on the cart will be balanced. Make slight adjustments to the height of the track until both values are the same at both A and B.

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Fs02 - Investigating Newton's 2nd Law using two Light Gates on the track

Read

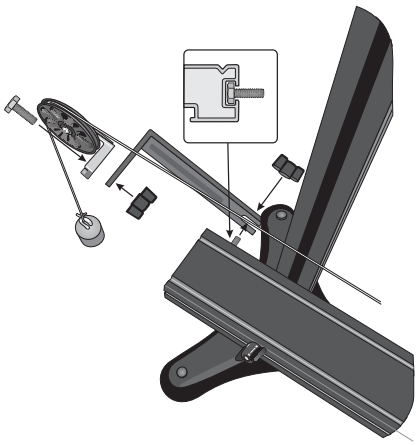
The condition for staying still or moving with a uniform velocity is that there is no resultant force acting on a body. Common experience tells us that objects at rest do not move unless a force is applied to them. The force that produces motion is the vector sum of all the forces acting on the object. If the resultant of these forces is zero then the object remains still or carries on moving with the same velocity. If the resultant force is greater than zero then the velocity will change in the direction of the resultant force.

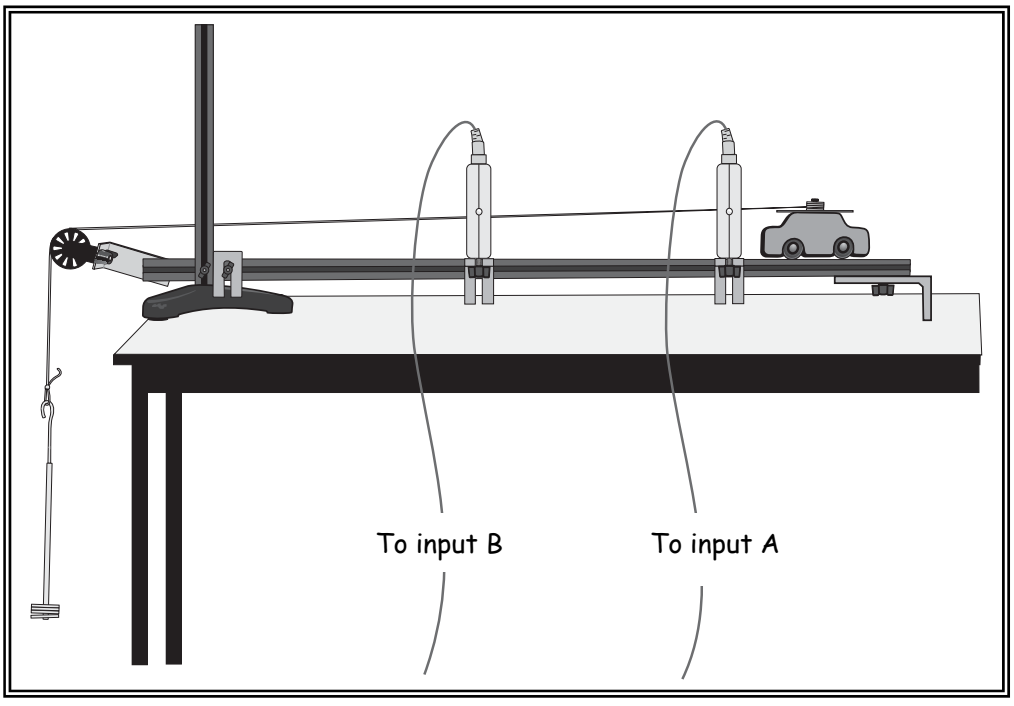
How does the velocity change when a steady resultant force acts on an object?

You are going to exert a steady force on a low friction cart and measure the change in velocity, i.e. the acceleration.

What you need

1. A Qt Digital Timer
2. 2 Smart Q Light Gates
3. Dynamics system track and pillar
4. A spoked pulley fitted to the end of the track using a thin bracket
5. 1 thin bracket to act as stop and 2 large brackets for a crash barrier - fitted close to the pillar
6. A length of string or thread
7. Dynamics cart with single interrupt card
8. 5 x 10 g masses and a 10 g hanger





Note: The cart must go through the Light Gate connected to input A first.

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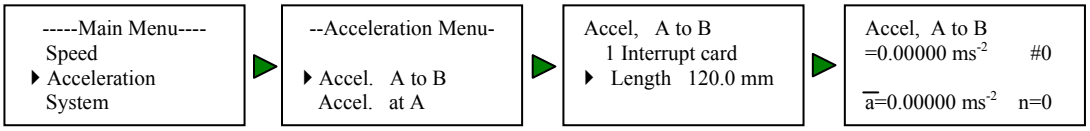
What you need to do

1. Assemble the Dynamics system as shown in the diagram (crash barrier not shown). Adjust the track to be accurately horizontal.
2. Place a thin bracket on the track close to the support pillar to act as an end stop. Place two large brackets alongside the track to act as a crash barrier.
3. Attach the spoked pulley to the end of the track using a thin bracket.
4. Position a Light Gate midway (about the 50 - 40 cm mark) and connect to input A on Qt. Position a second Light Gate nearer the pillar end of the track (about the 80 cm mark) and connect to input B.
5. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gates.
6. Place 50 g in weights on the top of the cart and secure in position (certain types of slotted masses can be secured using a thumbscrew).
7. Weigh the cart and all attachments (interrupt card and masses), to measure the 'total moving mass'. Note this value.
8. Connect a length of string (with a mass carrier attached) to the cart. Run the string over the top of the pulley.
9. Set up the Qt to measure **Acceleration from A to B** with 1 interrupt card that has a length of 120 mm:



10. Start with the cart at the 0 cm end and release to run freely along the track through the two Light Gates.
11. Take the cart back to the start **without** passing through the Gates. Repeat this reading at least three times. Write the average acceleration value in a results table like the one below.
12. Press the red ■ button to stop. Press ▼ to scroll to Repeat experiment and press ► to select. Transfer 10 g from the cart to the hanger and repeat.
13. Carry on repeating until all the weights have been transferred to the hanger. The total moving mass of the cart and hanger must be the same for all repeats.

Analysing your results

Total moving mass = ……..kg

Falling Mass (g)	Accelerating force (N)	Average acceleration (ms^{-2})

- Draw a graph of accelerating Force vs. average acceleration.

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Questions

1. Describe the shape of the graph.
2. What does the graph tell you about the relationship between the resultant force and the acceleration?
3. Calculate the gradient of the graph.
4. What quantity is the gradient a measure of?
5. There is probably a positive intercept on the Force axis. Explain what this intercept measures.

Extension

Repeat the experiment using different masses, but keeping the resultant force constant.
Draw graphs of acceleration vs. Mass, and acceleration vs. 1/Mass.
What is the relationship between acceleration and Mass if the Resultant Force is constant?

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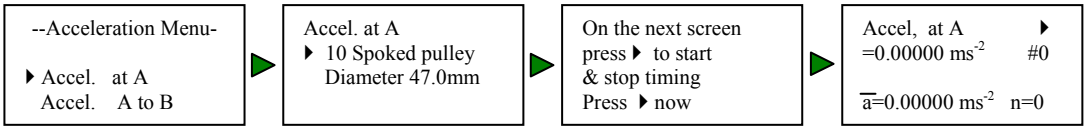
Teacher's notes for Fs03

In this investigation a spoked pulley is used to produce a continuous stream of data for determination of Newton's 2nd Law.

Setup of Qt



Notes

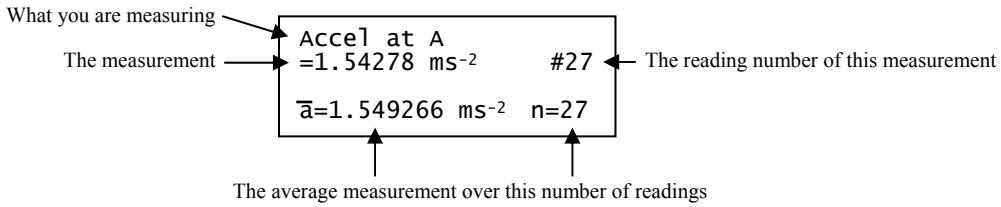
Check that the cart is running well by testing it along a horizontal track. If it is not running freely lubricate the bearings of the cart with WD40 (a light silicon based lubricant) or alcohol.

Place a thin bracket on the track to act as an end stop close to the vertical pillar. Use two large brackets as crash barriers in front of the end stop to help prevent the cart from jumping off the track.

Adjusting the slope of the runway to compensate for friction will give more accurate results – see Fs01. This will require the use of two Light Gates.

Using the track in the horizontal position will still give a good straight line for Force vs. acceleration, but with a bigger intercept on the axes.

Results and analysis


What you are measuring
The measurement
Accel at A
=1.54278 ms-2 #27
ā=1.549266 ms-2 n=27
The reading number of this measurement
The average measurement over this number of readings

The average measurement can be read from the bottom line of the display. You can scroll back through the values by using the ▲▼ buttons on Qt.

If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment.

To review a data set on Qt, press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

Sample results

Total moving mass = 0.397 kg

Falling Mass (kg)	Acceleration (m/s/s)	Accelerating Force (N)
0.01	0.272514	0.0981
0.02	0.531735	0.1962
0.03	0.790795	0.2943
0.04	1.043896	0.3924
0.05	1.302573	0.4905
0.06	1.549266	0.5886

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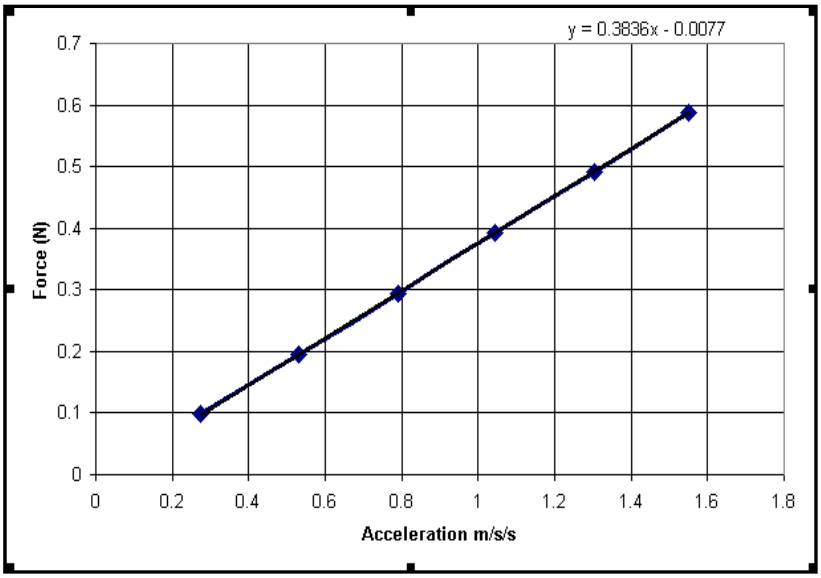
The data gave the following graph (shown drawn in Excel):



Gradient = 0.3836 kg, which is within 2% of the measured ‘total moving mass’.

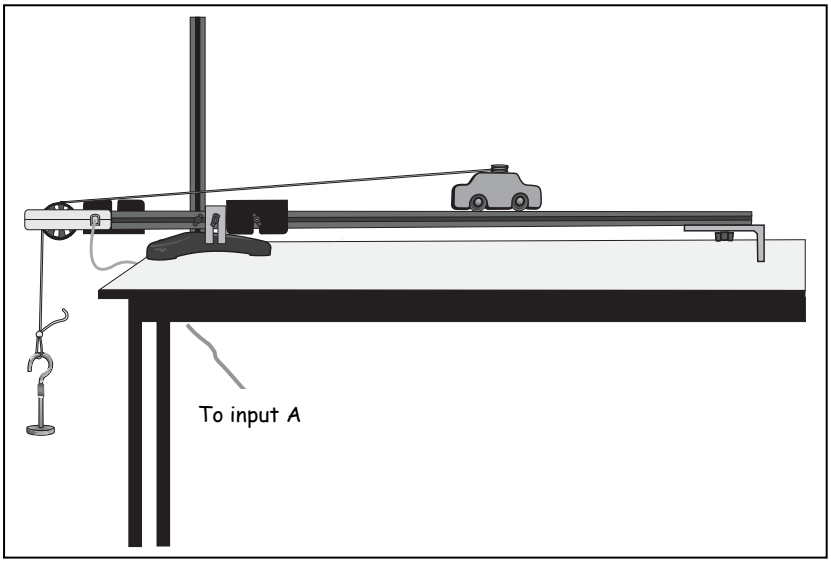
Fs03 – Investigating Newton's 2nd Law using one Light Gate and a spoked pulley on the track

Read

Force is needed to speed something up, or to slow it down. When bringing a car to a stop, we have to tread on the brakes very hard to bring the car to a stop in an emergency. What is the relationship between the applied force and the acceleration/deceleration that is produced? In this experiment you are going to measure the acceleration produced when you apply different forces to a mass.

What you need

1. A Qt Digital Timer
2. 1 Smart Q Light Gate fitted with a spoked pulley
3. Dynamics system track and pillar
4. 1 thin bracket to act as stop and 2 large brackets for a crash barrier - fitted close to the pillar
5. 1 large bracket to attach the Light Gate
6. A length of string or thread
7. Dynamics cart
8. 5 x 10 g masses and a 10 g mass hanger



What you need to do

1. Assemble the Dynamics system as shown in the diagram. Adjust the track to be accurately horizontal.
2. Attach the Light Gate with pulley attached to the end of the track and connect to input A on Qt.
3. Place a thin bracket on the track close to the support pillar to act as an end stop. Place two large brackets alongside the track to act as a crash barrier.
4. Fit the interrupt card to the cart so the **single** interrupt edge will pass through the Light Gates.
5. Place 50 g in weights on the top of the cart and secure in position (certain types of slotted masses can be secured by using a thumbscrew – TS1).
6. Weigh the cart and all attachments (interrupt card and masses), to measure the 'total moving mass'. Note this value.

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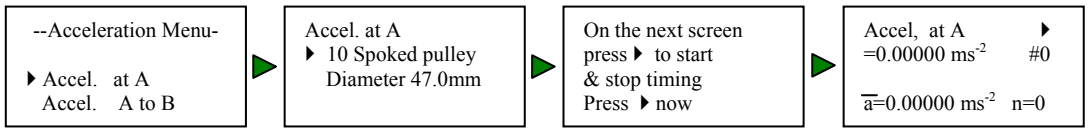
7. Connect a length of string (with a mass carrier attached) to the hook. Run the string over the top of the pulley.
8. Set up the Qt to record **Acceleration at A** with a spoked pulley:



9. Release the cart from near the 40 cm mark and **immediately** press the ► button on Qt to begin logging. Press ► again to pause logging **before** the cart **hits the stop** at the end of its run.
10. Scroll through the values using the ▲▼ buttons to check for any anomalous results e.g. when the cart hit the stop. If none write the average acceleration value in a results table like the one below. If some then discount these results and repeat the experiment

    Note: To make sure the value for average acceleration is correct it is important to press the ► enter button to pause logging before the cart hits the stop.

11. Press the red ■ button to stop. Press ▼ to scroll to Repeat experiment and press ► to select. Transfer 10 g from the cart to the hanger. Take the cart back to the 40 cm mark **without** passing through the Gates and repeat.
12. Carry on repeating until all the weights have been transferred to the hanger. The total moving mass of the cart and hanger must be the same for all repeats.

Analysing your results

Total moving mass = ……kg

Falling Mass (g)	Accelerating Force (N)	Average acceleration (ms^{-2})

- Draw a graph of Force vs. average acceleration.

Questions

1. Describe the shape of the graph. What does the graph tell you about the relationship between the resultant force and the acceleration?
2. Calculate the gradient of the graph. What quantity is the gradient a measure of?
3. There is probably a positive intercept on the Force axis. Explain what this intercept measures.

Extension

Repeat the experiment using different masses, but keeping the Resultant Force constant. Draw graphs of acceleration vs. Mass, and acceleration vs. 1/mass. What is the relationship between acceleration and Mass if the Resultant Force is constant?

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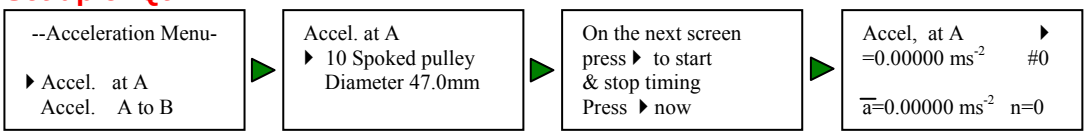
Teacher's notes for Fs04

Read

Atwood's machine is two masses hanging either side of a free running pulley. The accelerating force is the difference between the weights of the two masses, while the moving mass is the total of the two masses. The accelerating force is varied by transferring small masses from one side to the other.

Functionally this experiment is identical to the more widely used version of a falling mass pulling a cart. The removal of the track and moving cart should reduce the effect of frictional forces.

Set up of Qt



Notes

If using the Dynamics system pillar attach the Light Gate and spoked pulley to the pillar using a **large** bracket. A thin bracket flexes too much when a Light Gate with 0.7 kg is hung on it.

Use about 700 g of mass divided over the two sides of the pulley. Make up 50 g on each side from 10 g masses to allow for movement from one side to the other.

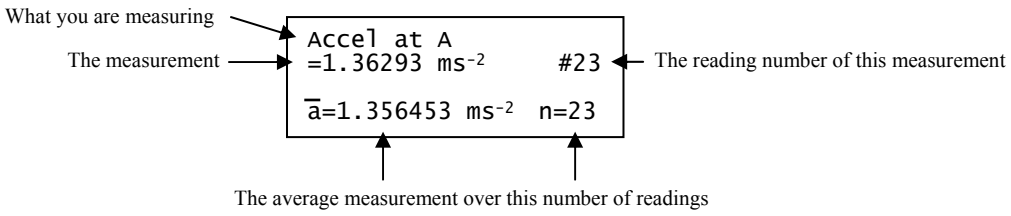
If a larger force/mass ratio is used then the acceleration may be too large to measure easily. If the masses are moving to fast it is difficult to start and stop the logging, and stop the masses from crashing.

Check the accuracy of the masses. If the stated mass is far from the actual mass, then weigh the masses accurately and use the measured masses. In the sample results, standard lab masses were used at their stated values.

It is wise to check that the pulley is running well. Lubricate the bearings with WD40 (a silicon based lubricant) or alcohol if it is not running freely.

Encourage the students to stop the masses before they clash or hit the ground/bench. The masses will be travelling at a considerable speed at the end of the runs with bigger forces.

Results and analysis


What you are measuring
The measurement
Accel at A
=1.36293 ms-2 #23
ā=1.356453 ms-2 n=23
The reading number of this measurement
The average measurement over this number of readings

The average measurement can be read from the bottom line of the display. You can scroll back through the values by using the ▲▼ buttons on Qt.

If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment e.g. with the angle of the slope.

To review a data set on Qt, press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

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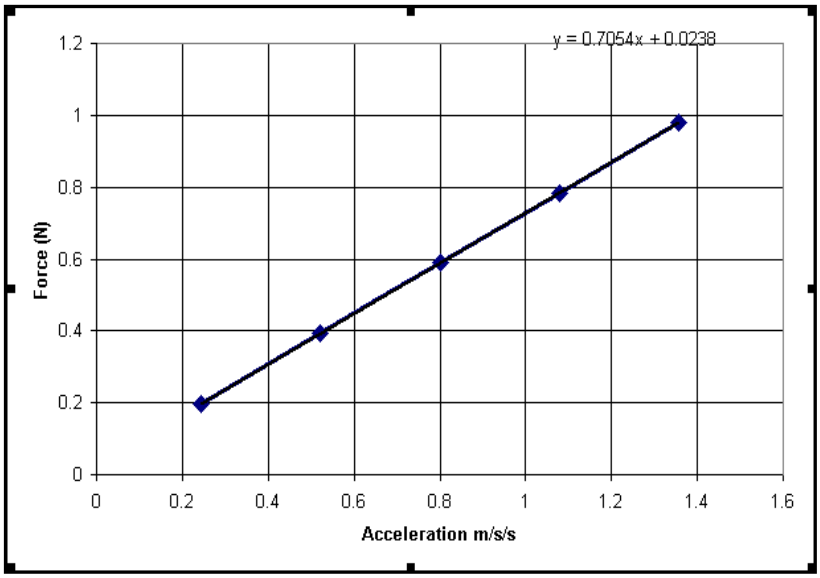
Sample results and analysis

Total moving mass = 0.70459 kg

Mass difference (kg)	Average acceleration (m/s/s)	Resultant Force (N)
0.02	0.244598	0.1962
0.04	0.522107	0.3924
0.06	0.800597	0.5886
0.08	1.079979	0.7848
0.1	1.356453	0.981

The data gave the following graph (shown drawn in Excel):



The gradient = 0.7054 kg which is within 1% of the stated value of the masses used (the accurately measured value for the total mass moving was 0.70459 kg).

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Fs04 – Investigating Newton's 2nd Law using one Light Gate and a spoked pulley (Atwood's Machine)

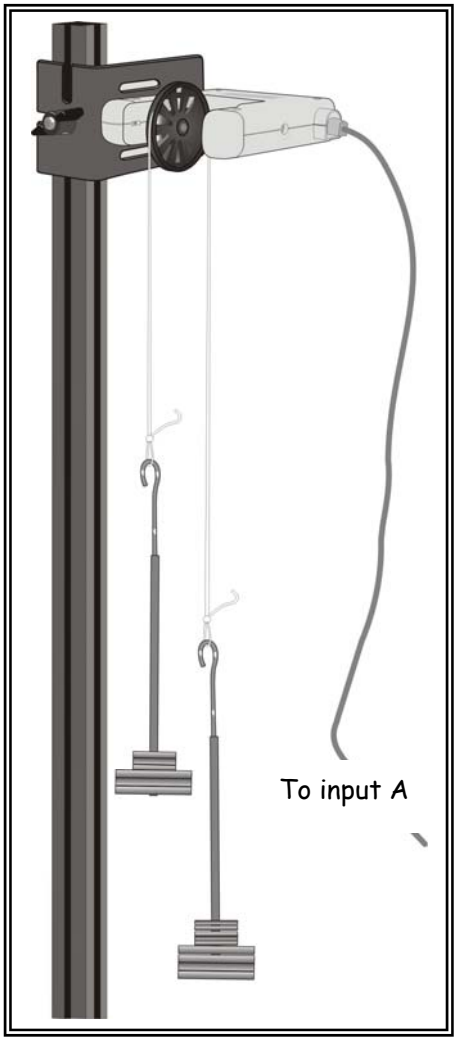
Read

Force is needed to speed something up, or to slow it down. When bringing a car to a stop, we have to tread on the brakes very hard to stop it in an emergency. What is the relationship between the applied force and the acceleration/deceleration that is produced?

In this experiment, you are going to measure the acceleration produced when you apply different forces to a mass.

What you need

1. A Qt Digital Timer
2. 1 Smart Q Light Gate with a spoked pulley fitted
3. Either the Dynamics system pillar with a large bracket to attach the Light Gate or a retort stand with bosshead
4. A length of string or thread
5. Masses and hangers (6 x 100 g and 10 x 10 g are suitable)



What you need to do

1. Start with 3 x 100 g and 5 x 10 g masses on both sides (side A and B). Note the value of the total moving mass in a results table.
2. Transfer 1 x 10 g mass from side A to side B. This will give a resultant force of 0.02 x g N. Note this value in a results table.
3. Arrange the set up so the heavier mass hangs below the lighter mass; this will stop the masses clashing as they move. The lighter mass should be able to move at least 400 mm, the heavier mass should reach a 'floor' before the lighter mass has reached the pulley.

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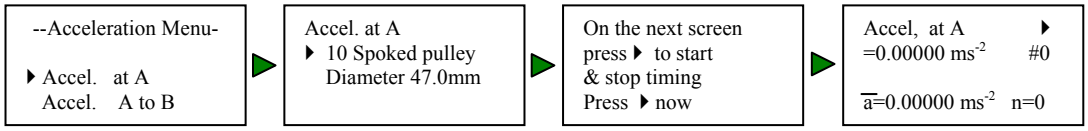
4. Set up Qt to record **Acceleration at A** with a Spoked Pulley:



5. Hold the masses in position, release and **immediately** press the ► button on Qt to begin logging. Press ► again to pause logging **before** the lighter mass reaches the pulley.
6. Scroll through the values using the ▲▼ buttons to check for any anomalous results. If none write the average acceleration value in a results table like the one below. If some then discount these results and repeat the experiment

   Note: To make sure the value for average acceleration is correct it is important to press the ► enter button to pause logging before the mass hits the pulley.

7. Transfer another 10 g mass from A to B. The force is now 0.04 x g N.
8. Press the red ■ button to stop. Press ▼to scroll to Repeat experiment and press ► to select.
9. Release the masses as before.
10. Continue to repeat, transferring 10 g, from A to B between each set of readings, until all of the 10 g masses are on B.

Analysing your results

Total moving mass = ...kg

Mass difference (g)	Resultant force (N)	Average acceleration (ms^{-2})

- Draw a graph of average acceleration vs. Resultant force. Draw the line of best fit.

Questions

1. Describe the shape of the graph.
2. What does the graph tell you about the relationship between the resultant force and the acceleration?
3. Calculate the gradient of the graph.
4. What quantity is the gradient a measure of?
5. There is probably a positive intercept on the Force axis. Explain what this intercept measures.

Extension

Repeat the experiment using different total masses, but keeping the Resultant Force constant. Draw graphs of acceleration vs. Mass, and acceleration vs. 1/mass.
What is the relationship between acceleration and Mass if the Resultant Force is constant?

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Teacher's notes for Fs05

Read

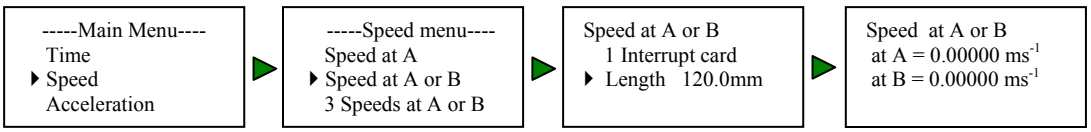
This investigation uses **two** Dynamics carts.

Note: An additional Dynamics cart is available to purchase separately (Product No 3821) or is available as part of the Dynamics system extension kit 1 (Product No 3801). The Dynamics system extension kit 1 also includes brackets, magnets, holders, springs and an interrupt card set.

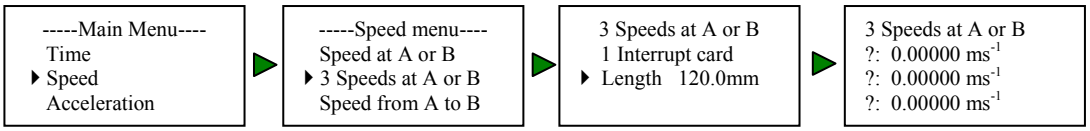
Either springs or magnets can be used for elastic collisions. The system does not require high speed collisions.

Set up of Qt

For all collisions using two identical carts, and inelastic collisions with carts of different masses use:



For elastic collisions using two carts of different masses use:



Notes

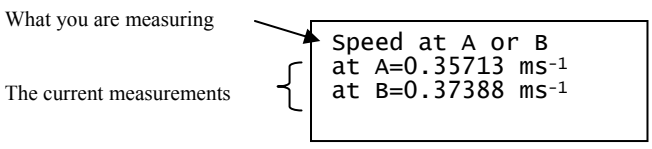
The friction force in the carts increases slightly with speed.

For accurate work, friction compensation is needed. Set Qt to log **Speed at A or B**, run a cart through and check the speeds. Adjust the track until the speed at A and B are the same. Use roughly the same speeds as you will use in the experiment.

Using friction compensation means that the carts can only move down the track. When using carts of unequal mass in elastic collisions, cart 1 needs to be substantially more massive than cart B so that both carts continue down the track after the collision. For the sample results we added 300 g to cart 1.

It is wise to check that the cart is running well, by running it along a horizontal track. Lubricate the bearings with WD40 (a silicon based lubricant) or alcohol if it is not running freely.

Results and analysis



If you intend to review a set of data or retrieve to the EasySense software it is useful to **Name the data set** before selecting Repeat experiment e.g. with the angle of the slope.

To review a data set on Qt press the red ■ button to stop logging. Select Main Menu and press the green ► button. Use the ▲▼ buttons to scroll to **Review data** and press the green ► button. Select the data set you've just created and press the green ► button.

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Sample results and analysis

The results of two identical carts **colliding** elastically **with a stationary cart of the** same mass:

At Gate A

Cart	Mass (kg)	Velocity at A (ms^{-1})	Momentum at A ($kgms^{-1}$)	Kinetic Energy at A (J)
Cart 1	0.336	0.37513	0.126	0.024

Cart	Mass (kg)	Velocity at A (ms^{-1})	Momentum at A ($kgms^{-1}$)	Kinetic Energy at A (J)
Cart 2	0.336	0.37388	0.126	0.023

The results of two **unequal mass** carts colliding **elastically:**

At Gate A

Cart	Mass (kg)	Velocity at A (ms^{-1})	Momentum at A ($kgms^{-1}$)	Kinetic Energy at A (J)
Cart 1	0.636	0.52222	0.0.332	0.0.087

Cart	Mass (kg)	Velocity at A (ms^{-1})	Momentum at A ($kgms^{-1}$)	Kinetic Energy at A (J)
Cart 1	0.636	0.1816	0.115	0.010
Cart 2	0.336	0.64986	0.218	0.071
Totals			0.334	0.081

Retrieving data

If the data is retrieved to the EasySense software it can be converted to Momentum and Kinetic Energy. To retrieve the data open the EasySense program, select Remote, **Retrieve Remote** from the Home screen, select the data set and click on Retrieve. The data will be displayed as a Time vs. speed graph

To display the data as Momentum and Kinetic Energy, select **Show Data as** from the Settings menu. Select Momentum and Kinetic Energy at A or B and insert the value of the masses and the single interrupt card.

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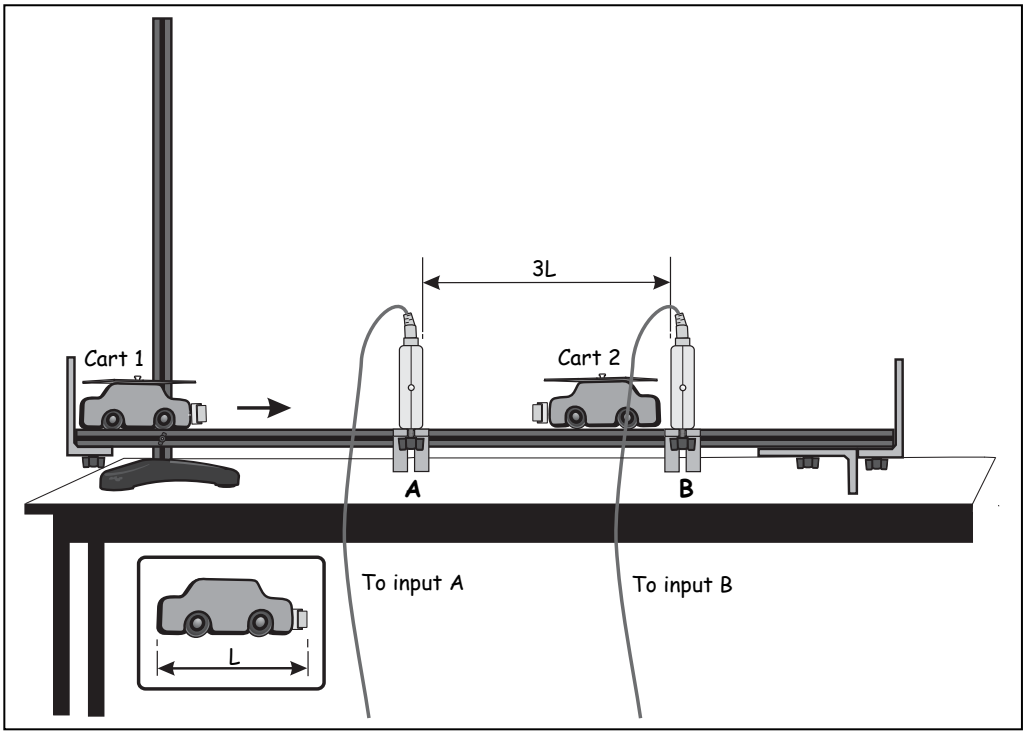
Fs05 – Investigating elastic and inelastic collisions using two Light Gates on the track (requires two carts)

Read

What happens to the energy and momentum in collisions? When a car bangs into another one there are transfers of energy and momentum. These experiments will investigate these transfers.

What you need

1. A Qt Digital Timer
2. 2 Smart Q Light Gates
3. Dynamics system track and pillar
4. 2 thin brackets to attach the Light Gates
5. 2 Dynamics carts each with single interrupt cards
6. Magnets and magnet holders and/or small buffers and springs
7. Crash barrier fitted to each end of the track
8. Modelling clay



What you need to do

1. Assemble the Dynamics system as shown in the diagram. Adjust the track to be accurately horizontal.
2. Connect the Light Gates to input A and B on the Qt. The Light Gates need to be spaced so that cart 1, and its interrupt card, can go completely through Gate A before the magnetic repulsion starts, and cart 2 does not go through Gate B until after the magnetic repulsion has finished. The distance between the Light Gates should be 3 times the length of the cart and attachments.
3. Fit an interrupt card to each cart so the **single** interrupt edge will pass through the Light Gates.

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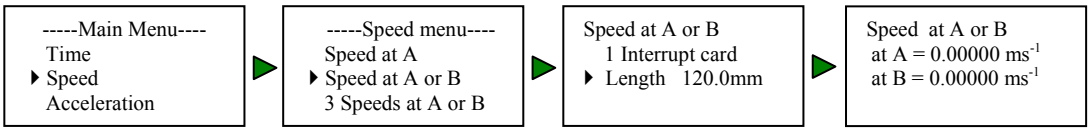
1. Elastic collision using magnets with two identical mass carts

1. Attach a magnet holder and magnet to the end of each cart with same poles facing.
2. Measure the mass of each cart and its attachments (interrupt card, magnets, etc) to make sure they are both equal. Use modelling clay to adjust until they are. Note the mass in a results table.
3. Position the 'target' cart' (2) between the two Light Gates (nearer B than A). Position the other cart (1) before Light Gate A. Start with the 'target' cart (2) stationary.
4. Make a few practice runs to see the velocities you can use to avoid hard collisions between the magnets.
5. Set up Qt to record **Speed at A or B** with 1 interrupt card that is 120 mm in length:



6. Push cart 1 towards cart 2. Note the values in a results table.

2. Elastic collision using springs with two identical mass carts

1. Repeat the experiment using springs instead of magnets. Measure the mass of each cart and its attachments (interrupt card, springs, etc) to make sure they are both equal. Use modelling clay to adjust until they are. Note the mass in a results table.

3. Inelastic collision with two identical mass carts

1. Repeat with the carts set up for inelastic collisions - mount a thumbtack on one cart and a cone of Blu Tack on the other cart.

2. Turn the interrupt card round on the leading cart (1) so that it does not interrupt the Light Gate.

Note: The two carts stick together as they pass through Light Gate B, so the total moving mass becomes the combined mass of both carts.

Analysing your results

1. Elastic collision using magnets with two identical mass carts

Mass of cart = ……kg

At Light Gate	Velocity (ms^{-1})	Momentum (kg m/s)	Kinetic Energy (J)
A			
B			

2. Elastic collision using springs with two identical mass carts

Mass of cart = ……kg

At Light Gate	Velocity (ms^{-1})	Momentum (kg m/s)	Kinetic Energy (J)
A			
B			

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3. Inelastic collision with two identical mass carts

Mass of cart = ……kg

At Light Gate	Velocity (ms^{-1})	Momentum (kg m/s)	Kinetic Energy (J)
A			

Mass of combined carts (Cart 1 + Cart 2) = ……kg

At Light Gate	Velocity (ms-1)	Momentum (kg m/s)	Kinetic Energy (J)
B			

Note: The two carts stick together as they pass through Light Gate B, so the total moving mass becomes the combined mass of both carts.

- Calculate Momentum and Kinetic Energy.

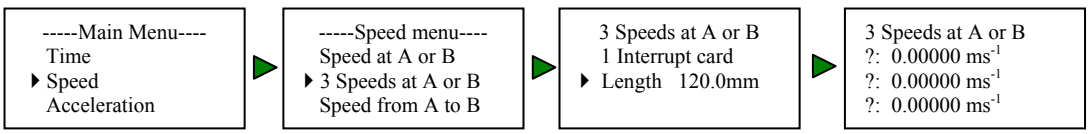
Momentum = Mass x Velocity
Kinetic Energy = ½ Mass x Velocity

- Analyse the data to compare the total momentum, and total kinetic energy before and after the collisions.

Extension

1. Elastic collision using carts of unequal masses

1. Make cart 1 the more massive, e.g. by adding at least a 0.3 kg mass to cart 1, so both carts will continue down the friction compensated track through Light Gate B after the collision.
2. Measure the mass of each cart and its attachments (interrupt card, springs, etc).
3. Set up Qt to record **3 Speeds at A or B** with 1 interrupt card that is 120 mm in length:



4. Push cart 1 towards cart 2, and allow **both** carts to pass through Light Gate B.

2. Inelastic collision using carts of unequal masses

1. Repeat with the carts set up for inelastic collisions – mount a thumbtack on one cart and a cone of Blu Tack on the other.
2. Turn the interrupt card round on the leading cart (1) so that it does not interrupt the Light Gate.

Note: The two carts stick together as they pass through Light Gate B, so the total moving mass becomes the combined mass of both carts.

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Analysing the results

1. Elastic collision using carts of unequal masses

Mass of cart 1 = ……kg

Mass of cart 2 = ……kg

At Light Gate	Velocity (ms^{-1})	Momentum (kg m/s)	Kinetic Energy (J)
A			
B (Cart 1)			
B (Cart 2)			

2. Inelastic collision using carts of unequal masses

Mass of cart 1 = ……kg

Mass of cart 2 = ……kg

At Light Gate	Velocity (ms^{-1})	Momentum (kg m/s)	Kinetic Energy (J)
A			

Mass of combined carts (Cart 1 + Cart 2) = ……kg

At Light Gate	Velocity (ms^{-1})	Momentum (kg m/s)	Kinetic Energy (J)
B (Cart 1)			
B (Cart 2)			

Note: The two carts stick together as they pass through Light Gate B, so the total moving mass becomes the combined mass of both carts.

Questions

1. From your results describe what happens to the total value of the Momentum of all the colliding objects during:-
   a) An elastic collision.
   b) An inelastic collision
2. From your results, describe what happens to the total value of the Kinetic energy of all the colliding objects during:-
   a) an elastic collision
   b) an inelastic collision
3. What happens to the kinetic energy that is 'lost' during an inelastic collision?
4. A 30 tonne lorry, travelling at 20 ms^{-1} collides with a stationary car of mass 1 tonne. They move along together after the collision.
   a) What is their velocity after the impact?
   b) Compare the Kinetic energies before and after the impact.

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Warranty

Qt Timer is warranted to be free from defects in materials and workmanship for a period of 12 months from the date of purchase provided it has been used in accordance with any instructions, under normal laboratory conditions. This warranty does not apply if Qt has been damaged by accident or misuse.

In the event of a fault developing within the 12-month period, Qt must be returned to Data Harvest for repair or replacement at no expense to the user other than postal charges.

Note: Data Harvest products are designed for **educational** use and are not intended for use in industrial, medical or commercial applications.

WEEE (**W**aste **E**lectrical and **E**lectronic **E**quipment) Legislation

Data Harvest Group Ltd is fully compliant with WEEE legislation and is pleased to provide a disposal service for any of our products when their life expires. Simply return them to us clearly identified as 'life expired' and we will dispose of them for you.

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